OCTOBER 1950

Journal

VOL. 42 • NO. 10

AMERICAN WATER WORKS ASSOCIATION

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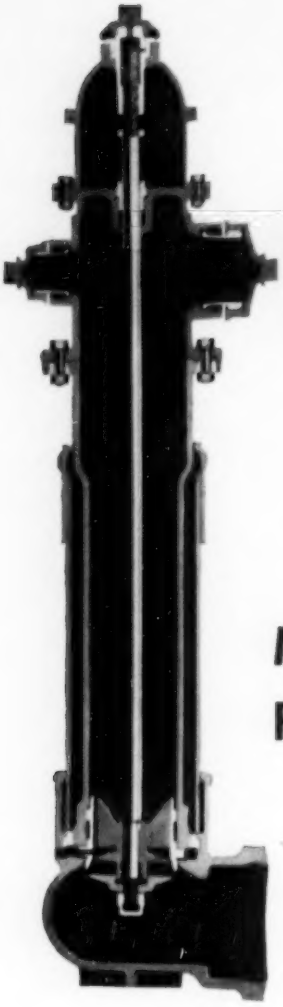

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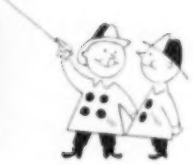

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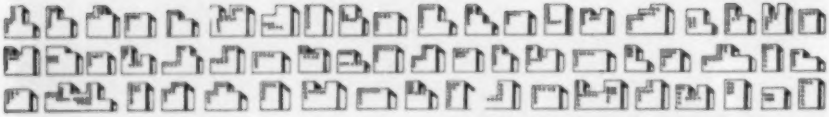

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October

11–13—Alabama-Mississippi Section at The Battle House, Mobile, Ala. Secretary: John L. Snow, Dist. Engr., Layne-Central Co., 601 First National Bank Bldg., Montgomery 4, Ala.

15–18—Southwest Section at Hotel Roosevelt, New Orleans, La. Secretary: L. A. Jackson, Mgr.-Engr., Little Rock Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

18–20—Pennsylvania Section at Hotel Roosevelt, Pittsburgh, Pa. Secretary: L. S. Morgan, Div. Engr., Penna. Dept. of Health, 415 First Natl. Bank Bldg., Greensburg, Pa.

23–25—Southeastern Section at Fort Sumter Hotel, Charleston, S.C. Secretary: T. A. Kolb, San. Engr., State Bd. of Health, Wade Hampton Bldg., Columbia, S.C.

23–25—Kentucky-Tennessee Section at Peabody Hotel, Memphis. Secretary: R. P. Farrell, Director, Div. of San. Eng., State Dept. of Public Health, 420—6th Ave., N., Nashville 3, Tenn.

24–27—California Section at U.S. Grant Hotel, San Diego. Secretary: W. W. Aultman, Water Purif. Engr., Metropolitan Water Dist. of Southern California, Box 38, La Verne, Calif.

25–27—Michigan Section at Leland Hotel, Detroit. Secretary: T. L. Vander Velde, Asst. Engr., State Dept. of Health, 2609 E. Saginaw St., Lansing 12, Mich.

(Continued on page 94)

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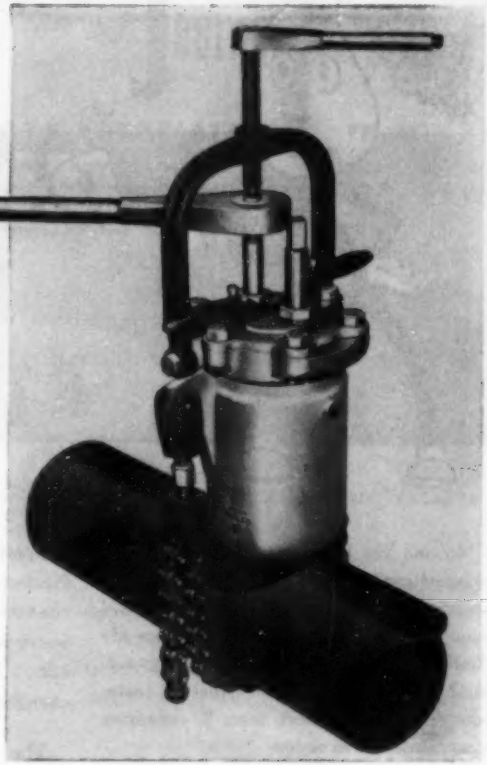

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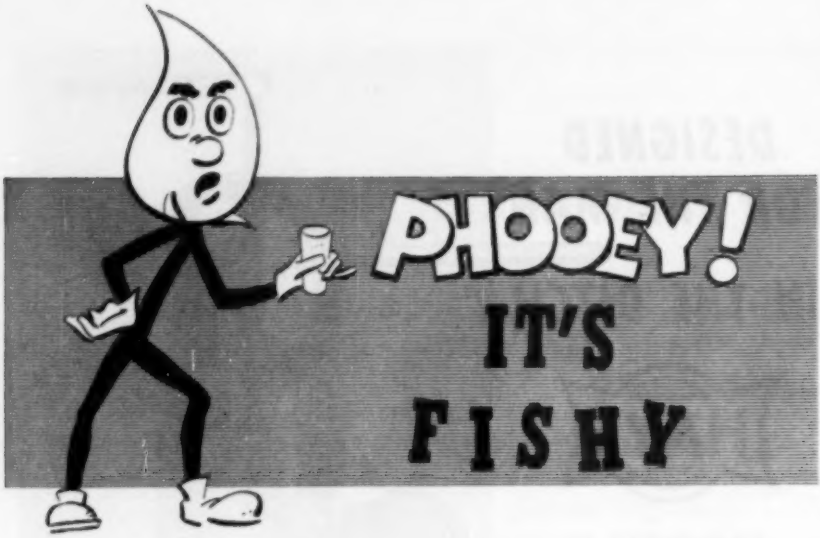

No one yet knows the exact chemical composition of algae, but it is common knowledge that algae cause tastes and odors in water supplies. These odors are characterized as fishy, aromatic, grassy, earthy, etc., and when they reach a taste-odor intensity of more than 5, consumer complaints are in order.

Aqua Nuchar Activated Carbon removes algae-caused tastes and odors from water because it actually removes the odorous compounds by adsorption. This Aqua Nuchar action is purely physical so that the tastes and odors are removed from the water when the activated carbon is filtered out . . . not merely changed or reduced by chemical reaction.

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Journal

AMERICAN WATER WORKS ASSOCIATION

Vol. 42 • No. 10
October 1950

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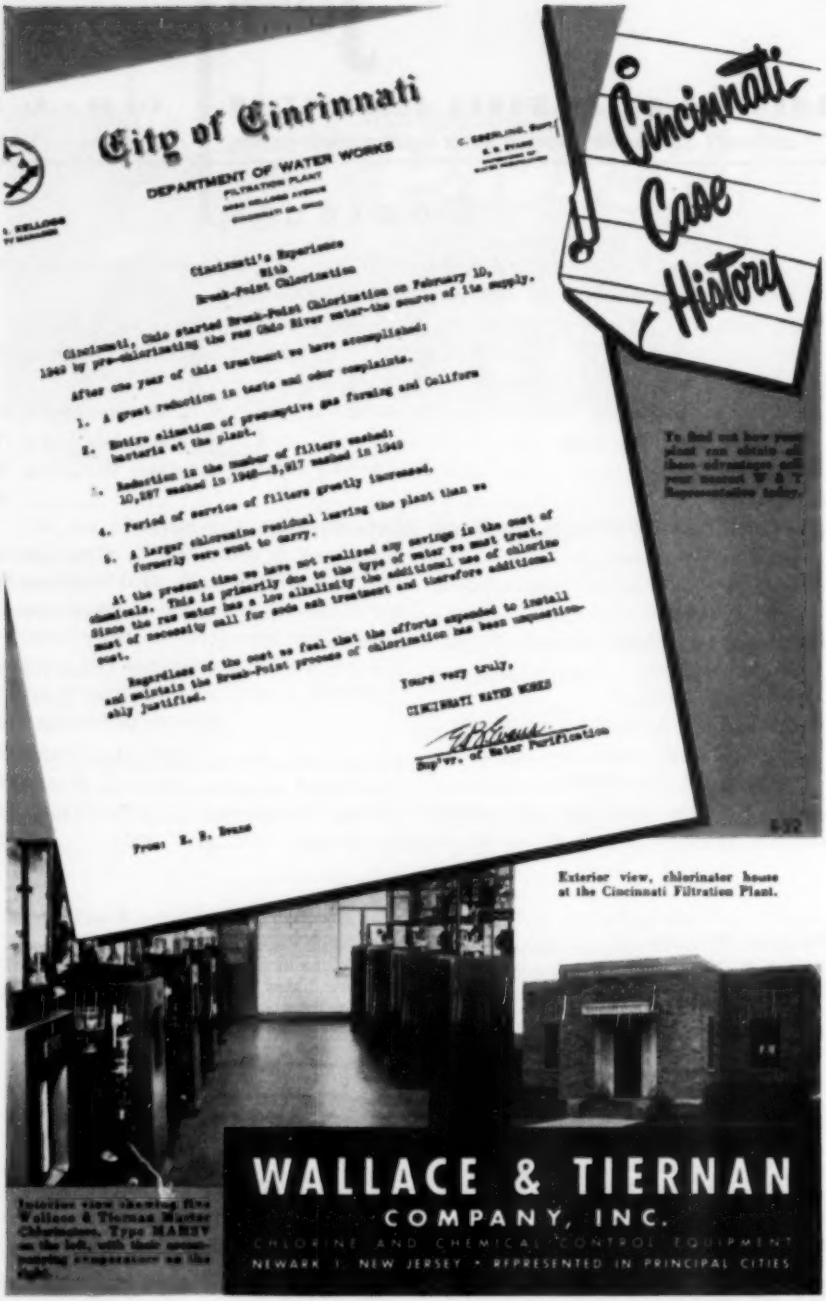
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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 42 • OCTOBER 1950 • NO. 10

State Pension and Retirement Legislation in 1949

Committee Report

A report, dated May 5, 1950, presented by Committee A2.D—Pension and Retirement Plans, D. L. Maffitt, Chairman. The other members of the committee are: R. W. Esty, L. E. Goit, M. P. Hatcher, A. P. Kuranz, Wade Plummer and L. A. Smith.

A BRIEF survey of pension and retirement legislation enacted in the various states in 1948 and 1949 indicates an increasing interest in planning for old-age retirement. New pension plans have been authorized in several states and there have been numerous amendments to previously established systems. In most instances, the laws and amendments passed are too detailed to be included in this report, but the summary given below may serve as a reference.

It is of interest that at least eight states—Arkansas, Idaho, Kentucky, North Carolina, Oklahoma, South Carolina, South Dakota and West Virginia—have already passed legislation authorizing their governing bodies to do whatever is necessary to bring their employees into the federal social security old-age and survivors' insurance system, if and when Congress amends the Social Security Act to make employees of states and their political subdivisions eligible for coverage. This legislation varies in the several states, and, where the new laws are not too long, they have been quoted in the summary.

[EDITOR'S NOTE: As originally submitted by the committee, this report contained a description of pending federal legislation amending the Social Security Act. Since the passage of such an amendment in August 1950 the committee has prepared a supplement to its report covering the new legislation. This supplement is given on p. 912, this issue, in place of the earlier material presented by the committee.]

Summary of 1949 Pension Legislation

Below is presented a state by state summary of 1949 pension legislation, also including 1948 legislation not previously reported.

Alabama. [1] Pension system authorized for city of Auburn. [2] Pension system authorized for city of Florence. [3] Retirement system authorized for employees of city water works boards and other public corporations in cities of 50,000 to 78,500 population. [4] Retirement system of city of Birmingham amended. [5] State public employees retirement system (established in 1945) amended. [6] Other special pension legislation amended.

Arizona. No pension legislation in 1949.

Arkansas. Following law (Act 305, Ark. 1949) relating to federal social security passed March 19, 1949:

An Act authorizing compacts between the State of Arkansas and the political subdivisions thereof and the Social Security Administration to extend Federal Old-Age and Survivors' Insurance coverage to employees of the State and political subdivisions thereof, including cities; providing for the assessment and collection of contributions upon wages of such employees; providing for an appropriation therefore; and for other purposes.

Sec. 1—Power to Accept Federal Aid: (a) When the Federal Social Security Act is amended to provide that the several states and political subdivisions thereof may so elect, the Governor for the State of Arkansas and/or the governing bodies of the separate political subdivisions of the State of Arkansas, including the head of any state department supported wholly by federal funds, are authorized to enter into compacts or agreements with the Federal Government and/or with the proper federal agency designated to administer the Federal Social Security Act, as amended for the purpose of extending old-age and survivors insurance coverage to employees of the State and political subdivisions thereof, respectively.

(b) The specific details of each such compact shall be entered into by the State, and/or each separate political subdivision which so elects, with the proper Federal Agency, but each compact shall provide:

1. That benefits will be provided for the employees of the State and/or such political subdivisions thereof on the same basis as for other employees covered by such insurance program.

2. That the State and/or such political subdivision thereof as may enter into compacts shall pay the employer's social insurance contributions and collect the social insurance contributions on employees in the manner and in the amounts specified by the Federal Insurance Contributions Act as amended.

3. That the State and/or such political subdivision thereof may terminate the compact in a manner consistent with the provisions of the Social Security Act as amended.

4. That each such compact shall become effective as may be designated by such compact.

5. This Act shall not apply to any board, instrumentality or portion of any political subdivision which may have a pension or retirement plan in effect at the time the Federal Social Security Act is amended as referred to in Sec. 1 (a) hereof.

(c) Every affected individual employee of the State and/or political subdivision which has entered into such compact as herein provided shall pay social insurance contributions equal to the per centum of wages as required by the Federal Act of any other employees covered by such act. The State and any political subdivision

thereof as shall enter into a compact shall collect such social insurance contributions in a manner as prescribed for other employers by the Federal Insurance Contributions Act as amended.

(d) The governing bodies of the respective political subdivisions of the State which shall enter into such compacts are authorized to appropriate out of the funds of their respective political subdivisions social insurance contributions as provided in the Federal Insurance Contributions Act, as amended, for the other employers and to pay such contributions as required to the Federal Treasury.

(e) If the federal amendments provide that all compacts with the Federal Security Administrator be entered into only by the State, then the Governor, acting for the State, may enter into agreements with the political subdivisions in such manner that the Governor may include such political subdivisions, or portions thereof, in the compact with the Federal Security Administrator in the name of the State.

California. Considerable pension legislation, but not specifically applying to water works.

Colorado. Amendments to plans already established.

Connecticut. [1] Retirement plan authorized for employees of town of Hamden. [2] Amendments to previously established plans of cities of Norwich and Milford, and to various individual established plans.

Delaware. [1] City of Milford authorized to establish and maintain pension system for employees. [2] Amendment to previous legislation regarding city of Wilmington. [3] Various amendments to state plan established in 1945.

Florida. [1] Amendment to Miami plan. [2] Pension system authorized for city of Wauchula. [3] Amendments to various established plans.

Georgia. Bill passed to establish retirement system to cover employees of state agencies, including county or city boards, under state merit system.

Idaho. Following law (Chap. 285, Idaho 1949) relating to federal social security passed March 16, 1949:

To provide for employees of the State of Idaho and political subdivisions thereof—including irrigation districts, fire protection districts, highway districts, drainage districts, and all political subdivisions which levy taxes and employ and pay salaries and wages to officials and employees—to participate in and receive benefits of the old-age and survivors' insurance provisions of the Federal Social Security Act 53 Stat. 1373 if and when said statute is amended to permit such participation.

Sec. 1. The State of Idaho, in behalf of all of its officers and employees and the officers and employees of all of its counties, cities, and towns and of any and all of its municipal corporations and political subdivisions which levy taxes and employ and pay salaries and wages to its officers and employees, hereby accepts the benefits of the provisions of the Federal Security Act 53 Stat. 1373, for Old-Age and Survivors' Insurance Benefits, whenever the provisions of such act are extended to embrace such officers and employees.

Sec. 2. Any and all officials, boards, commissions, directors and boards having charge of preparation of payrolls and payment of salaries and wages to officers and employees of the State of Idaho, or any of its political subdivisions as set forth in Sec. 1, are hereby authorized and directed to make payroll and salary and wage deductions and to handle and dispose of the same as required by the Federal Social Security Act, as amended to include such officers and employees within the eligible group, and any official or

board being authorized to disburse funds for the salary or wages of any officer or employee who shall come within such eligible group is authorized to pay and disburse out of any funds available for operation and maintenance such sums, and dispose or handle the same in such manner as is required and necessary to make payments and benefits of said Federal Social Security Act available to such officers and employees who shall become eligible.

Sec. 3. Nothing contained in this Act shall deprive any person of benefit under any existing retirement system, nor repeal, amend, modify or supersede any law, charter amendment or ordinance establishing or pertaining to an existing retirement system.

Sec. 4. Each department and agency of the State of Idaho, and each political subdivision as defined in Sec. 1, which shall pay and disburse salary and wages separately shall have 90 days from and after the date when the Federal Social Security Act shall be amended . . . within which to take the necessary steps to include its officers and employees within such eligible group.

Illinois. [1] Amendment to state retirement and pension system. [2] Detailed amendment on Chicago Sanitary Dist. employees annuity and benefit fund. [3] Amendment on employees annuity and benefit fund in cities of over 200,000 population. [4] Amendment on Illinois municipal public utility employees annuity and benefit fund. [5] Amendment on municipal employees annuity and benefit fund.

Indiana. No pension legislation in 1949.

Iowa. Amendment to Iowa old-age and survivor insurance system: [1] increasing the tax to be paid to the fund by employer and employee from a maximum of 2 per cent each on taxable salaries to a maximum of 3 per cent each in 1950 and 4 per cent each in 1951 and thereafter, until necessary to increase it further to keep the plan actuarially sound; [2] increasing the maximum benefits and changing the pension formula to increase the primary benefit and give additional benefit predicated on length of service; [3] increasing the amount of wages that may be earned in covered employment after retirement from $15 per month to $25 without affecting payment of pension; and [4] excluding temporary employees of the General Assembly of Iowa, unless such employees make application for coverage.

Kansas. Amendments to existing legislation.

Kentucky. Following law (Chap. 129, Ky. 1948) relating to federal social security passed March 24, 1948:

An Act authorizing retirement and disability plans for employees of cities, counties and their agencies.

Sec. 1. Cities of all classes and counties and the agencies of cities and counties are authorized to establish and operate plans for the payment of retirement, disability or hospitalization benefits to their employees. Such a plan may require employees to pay a percentage of their salaries into a fund from which benefits are paid, or the city, county or agency may pay out of its own funds the entire cost of the benefits. A plan may include a combination of contributions by employees and by the city, county or agency into a fund from which benefits are paid, or it may take any form desired by the city, county or agency. Each city, county or agency may make rules and regulations and do all other things necessary in the establishment and operation of such a plan. The term "agency" as used herein shall include boards appointed to operate water works, electric plants, hospitals, airports, housing projects, golf courses, parks, health departments or any other public project.

Sec. 2. In the event the Congress of the United States extends the Social Security Act to cover employees of cities, counties and their agencies, such cities, counties and their agencies are authorized to participate in the United States Social Security program by doing any and all things necessary to provide their employees with retirement or disability benefits or any other benefits that may be provided by that program.

Sec. 3. The provisions of this act shall be in addition to any other authority of cities, counties and their agencies to provide retirement and disability benefits for their employees, and shall not repeal or modify any acts except those that may be in conflict with this act.

Louisiana. [1] State employees retirement plan established in 1946 amended in 1948; does not appear to apply to cities and towns; 1948 amendment provides, among other things, for refund of members' contributions upon withdrawal from service before they are entitled to pension; also provides for death benefit to beneficiary. [2] Law passed in 1948 providing that proposed constitutional amendment on pensions for employees of municipalities with more than 13,000 population be submitted to voters in November 1948 election; no report of result of election. [3] Act approved, effective July 17, 1948, authorizing municipalities with population between 20,000 and 90,000 to adopt ordinances establishing actuarially sound pension and retirement systems to cover their elective and appointive officers and employees and to exclude all officers and employees already covered by some pension and retirement system. [4] Act approved, effective July 24, 1948 (amending Sec. 13 of Act 6 of the Extra Session of 1899, relative to establishing and defining powers and duties of New Orleans Sewerage and Water Board), authorizing board to retire employees under certain conditions of the act and to make such rules and regulations as necessary for this purpose. [5] Act approved, effective July 24, 1948, authorizing retirement system for employees of city of Alexandria; act describes plan in detail.

Maine. No legislation in 1948 or 1949.

Maryland. Amendments to established plans.

Massachusetts. Numerous amendments to existing legislation.

Michigan. Amendments to established plans.

Minnesota. No legislation in 1948 or 1949.

Mississippi. [1] Act approved April 8, 1948, authorizing municipalities with population of 20,000 or more, which are located on Mississippi River and in which there is a National Military Park, to create general municipal employees retirement system. [2] Act approved March 31, 1948, authorizing municipalities with population of 21,000 or more, operating under commission form of government, to establish general municipal employees retirement system to cover certain employees.

Missouri. No legislation in 1948 or 1949.

Montana. No legislation in 1949. (Public employees' retirement act passed in 1945 and amended in 1947 permits cities to participate.)

Nebraska. No legislation in 1949.

Nevada. Act approved April 22, 1949, amending public employees retirement act of 1947.

New Hampshire. No legislation in 1949.

New Jersey. Amendments in 1949 to legislation previously passed.

New Mexico. [1] Amendment, approved March 14, 1949, to public em-

ployees retirement law of 1947, providing for emeritus status of retirement for municipal employees under certain conditions. [2] Extensive amendment of Chap. 157, Session Laws of 1947, which established retirement system for public employees, including state, county and city; amendment appears to be written with intent of making law more inclusive; original law provided for election to participate, whereas amended law provides method of exemption from participation.

New York. [1] Amendments in 1949 to New York City pension law. [2] Proposal in 1950 (not yet passed) that civil service retirement law for state employees be liberalized to permit retirement at age 55, with state bearing part of additional cost; present law permits retirement at age 55, but retiring employee must contribute large amount in order to receive pension.

North Carolina. [1] Amendments in 1949 to general state plan and also to various local plans. [2] Following amendment (Chap. 103, N.C. 1949) relating to federal social security passed February 17, 1949:

> An Act to amend Sec. 160–200 (25) of the General Statutes of North Carolina so as to enable the municipalities to qualify for participation in the Federal Social Security Act if and when the Congress of the United States extends its provisions to include municipal employees
>
> *Sec. 1.* Amend Sec. 160–200 (25) of the General Statutes of North Carolina by adding the following at the end thereof: "If and when the Congress of the United States amends the Federal Social Security Act so as to extend its provisions to include municipal employees, each municipality is hereby authorized to take such action or to appropriate such funds as are necessary to enlist their employees therein."
>
> *Sec. 2.* This Act shall be in full force and effect from and after its ratification.

North Dakota. [1] Amendment in 1949 to plan authorized in 1947, defining employer as "State of North Dakota, the counties, municipalities and all of the political subdivisions thereof, and all of their departments and instrumentalities," except those now or hereafter covered by a retirement plan, in which event such political subdivision may by election come under the state plan. [2] Amendment to "City Employees Pension Act of 1943," permitting cities to withdraw from state plan (1947) on election, and containing other provisions.

Ohio. Minor amendments to legislation previously passed.

Oklahoma. Amendment, effective June 1, 1949, to Title 51, Officers, 1949, Oklahoma Statutes Supplement 1949, adds "Chapter 4, Old-Age and Survivors Insurance under Federal Act (New)" to state law. This is very detailed act providing for coverage of certain officers and employees of state and local governments under Federal Old-Age and Survivors' Insurance Act.

Oregon. Several detailed amendments to Oregon public employees retirement act of 1945.

Pennsylvania. [1] Amendments to certain "special city" and "special county" retirement plans. [2] Apparently no change in municipal employees retirement system created in 1943 and amended in 1945 and 1947.

Rhode Island. [1] Legislation in 1949 authorizing certain cities to make special retirements. [2] Following resolution (No. 114, H. 532) regarding federal social security passed February 4, 1949:

> *Resolved,* that the senators and representatives from Rhode Island in the Congress of the United States be and they

are hereby requested to use their efforts to amend the Federal Social Security Act with the purpose of extending the coverage and the benefits now authorized by such legislation; *and be it further resolved*, that the secretary of state be and he is hereby authorized and directed to transmit duly certified copies of this resolution to the senators and representatives from Rhode Island in the Congress of the United States.

South Carolina. [1] Amendments in 1948 to general state plan in which local governments may participate, one amendment permitting application for refund of contribution if employee leaves covered employment. [2] Amendment in 1949 virtually rewriting act of 1945 establishing state retirement system in which municipalities may participate; Sec. 10 of amended act states:

> The State of South Carolina hereby reserves the right that, should the Federal Social Security Act be so amended that the members or beneficiaries of the system can be included in the Old-Age and Survivors' Insurance Plan provided for in the said Federal Act, then, and in that event, the [state] system may be revised upon a fair and equitable basis so that the members or beneficiaries of the system may be included under the provisions of the said Federal Act.

South Dakota. [1] General pension legislation for cities of first class, amending South Dakota Code 45.12 in some detail. [2] Act approved March 5, 1949, authorizing in some detail state participation in federal social security plan.

Tennessee. Amendment passed adding the following to Sec. 2, Chap. 33, Public Acts of Extra Session of 1935, relative to acquisition, maintenance, improvement and operation of public works by cities and towns: "In the event a municipality establishes a pension plan for employees of such public works, expenditures incident to inaugurating and maintaining such plan shall be deemed operating expense for purposes of this section."

Texas. [1] Proposed constitutional amendment which would permit officers and employees of counties to participate in statewide pension system supposed to be submitted to voters in November 1949, but result of this election not known. [2] Detailed amendment to municipal retirement act of 1947.

Utah. Minor amendments in 1949 to retirement law passed in 1945, authorizing pension systems in cities of first class (amended in 1947 to extend to cities of second and third classes and incorporated towns).

Vermont. Detailed amendment in 1949 providing that local governments may participate in state employees retirement system by election of local government.

Virginia. Amendment in 1948 to general state plan which applies to municipalities.

Washington. [1] Detailed amendment to Chap. 71, Laws of 1947, city employees retirement system. [2] Detailed amendment to Chap. 274, Laws of 1947, state employees retirement system.

West Virginia. Detailed law passed in 1949 providing for coverage under federal social security law on broad basis, if permitted by federal law, and authorizing state agencies, with approval of governor, to make agreements with federal agencies for this purpose.

Wisconsin. Detailed amendments to existing plans.

Wyoming. Act passed in 1949 creating state employees retirement association, but not covering city employees.

Federal Social Security Act Amendment, 1950

An amendment to the Social Security Act, signed into law by the President on August 28, 1950, included an extension of benefits to employees of state and local governments *not now protected* by a retirement system, *if they elect to come under the federal program.*

Other groups newly covered by the law include certain classes of self-employed persons, domestic servants, regularly employed farm workers and employees of nonprofit organizations—all subject to special provisions of the law.

The majority of the states have passed legislation either to establish state pension systems or to permit governing bodies within the states to set up their own systems. The employees of publicly owned water works who are covered by a state plan, or by a municipal or individual plan, will not be eligible to participate in the federal social security benefits.

The eight states which have already passed legislation relating to federal social security are now in a position to secure federal benefits for their public employees, provided such employees are not covered by individual systems.

Under the 1950 amendment to the federal law, retirement benefits to those already retired under the federal law will increase about 77 per cent, as of October 1, 1950, and benefits for those yet to retire will be about double. Minimum benefits will increase from $10 to $20 a month; maximum benefits for a family will increase from $85 to $150 a month; and average monthly benefits will increase from $26 to about $46.

The social security payroll tax was 1 per cent on employees, and 1 per cent on employers from 1936 to 1949, inclusive. The present tax is 1½ per cent on employees and a like amount on employers. The tax will increase to 2 per cent on each in 1954, 2½ per cent in 1960, 3 per cent in 1965 and 3¼ per cent in 1970. Originally the tax applied only to the first $3,000 of annual salary, but the 1950 amendment increases this maximum to $3,600, starting January 1, 1951.

Management Experience With Metering Multiple Dwellings

Panel Discussion

A panel discussion presented on May 22, 1950, at the Annual Conference, Philadelphia.

Harry B. Shaw

Deputy Chief Engr., Washington Suburban San. Commission, Hyattsville, Md.

DURING the recent New York City water shortage, a proposal to meter multiple dwellings received considerable attention. A number of problems were brought out which it is hoped this panel discussion may help to clarify.

Information on this subject was obtained by the author from ten owners of large apartment developments in the Washington Suburban Sanitary Dist. All the owners paid for the water supplied to tenants. Six stated that the tenants were not wasteful, two said they were and two did not know.

The answers were accompanied by some interesting comments. Five owners stated that they systematically had maintenance crews check apartments in the buildings for plumbing leaks; the inspection period varied from a month to a year. Two owners said that, to prevent tenants from washing their automobiles, they were not permitted to use outside water connections. Three owners noted that tenants promptly reported leaks because they did not want to be annoyed by dripping faucets or running toilets.

None of the operators had adopted any definite plan to control tenants who waste water. One said that sometimes other tenants notify the management when a neighbor is using water at odd hours. In that event, the tenant is requested to be more careful. Another reported that tenants who were thought to be wasting water were asked not to do so and were warned that if they did not cooperate the management could "take the necessary steps to secure possession of the apartment, using gross wastefulness of water as grounds." It should be observed that this reply was received from an apartment management company, not from an owner.

All those queried stated that they had no arrangement to pass on excess water bills to tenants.

Because the apartment developments surveyed were carefully chosen to give a representative picture, the replies would indicate that, generally, in Washington Suburban Sanitary Dist. multiple-dwelling units:

1. The owner pays for the water used.
2. Tenants are not usually wasteful of water and plumbing is systematically inspected for leaks.
3. Most apartment development operators do not have a plan for controlling tenants who are wasteful, but this is probably because there is no great necessity for it.
4. There is no arrangement for passing excessive water costs on to the tenants, again probably for the reason that there is little necessity to do so.

It should be mentioned that, in the Washington Suburban Sanitary Dist., apartment developments are served through a master meter but pay the same rate as individual residences—that is, they do not have a sliding rate scale.

Although the replies to the questionnaire indicate that, in the owners' opinion, tenants of apartments generally are not wasteful in the use of water, figures compiled in the office of the Washington Suburban Sanitary Commission within the past year show that such tenants apparently use considerably more water than people who live in separate dwellings. The mean per capita water consumption per separate dwelling—occupied, on the average, by 3.8 persons in the sanitary district—is 47.5 gpd. One check of 2,857 apartment units, averaging an estimated 2.75 persons each, showed an average per capita consumption of 69 gpd.; another check indicated that 1,072 dwelling units (consisting of 764 one-bedroom, 268 two-bedroom and 42 three-bedroom apartments), with a population of 2,806, used 79,380,000 gal. of water in 1949, or an average per capita consumption of 77.3 gpd. The average per capita water consumption in the sanitary district, including all nonbilled water, is 80 gpd.

W. A. Glass

Director, Dept. of Water & Sewers, Miami, Fla.

Since the first water franchise granted in 1900, Miami, Fla., has been 100 per cent metered. There are approximately 6,000 apartment buildings in the Miami area, all of which are being satisfactorily served by master meters. The trend at present, in the newer buildings, is toward individual metering, but this is at the owner's preference and is not a requirement of the department. The department's rules and regulations state that: "When two or more premises are served through the same meter, the owner must sign the contract or contracts for water service and be responsible for the payment of all service rendered, since no method is available to the Department for prorating charges for service among the occupants of the several premises."

If the various steps or blocks of the water rate schedule are well balanced —that is, if they properly cover all the costs—master metering is equitable for the water department and is just as beneficial to the owner as if the individual units were metered.

From the owner's point of view, his plumbing costs are materially reduced if a master meter is used instead of individual meters. Moreover, his tenants are relieved of ordering connections and disconnections every time they move. In a tourist community like Miami, these innumerable connections and disconnections would result in the utmost confusion.

The president of the city's largest apartment management company states that, over a period of 25 years, his company has found master metering highly satisfactory; in fact, his company would object strenuously if a change to individual metering should be contemplated or prescribed. The president points out further that the use of water is not subject to waste to the same extent as electricity, for instance. Because there are not so many uses for water, waste and leaks are quite easily discovered and checked. All of the larger buildings in the Miami metropolitan area have resident managers, whose duty it is to see that needed plumbing repairs are promptly made so that there will not be an

appreciable waste of water due to leaks.

It has been claimed that master metering gives an opportunity to tenants to be wasteful, especially when trouble between a tenant and the owner arises. Miami's experience, however, has been that most people are fair-minded, honest and cooperative.

It must not be forgotten that the bill for water service is so negligible, compared with the total operating expenses of a multiple-unit building, that the cost can be readily absorbed in the rent. In Miami, water service is so generally furnished and included in the rent that tenants do not even inquire who is responsible for it.

It is the author's understanding that water is provided in all low-cost Federal Housing Authority projects, the cost being included in the rent. Under an arrangement of this kind, the private owner would have a distinct advantage, for accurate estimates could be made prior to construction and considered in the rental asked, in the same way as all other costs.

In the author's opinion, it is now generally recognized that all water service should be metered. To attempt to charge for water consumed on the basis of the total number of outlets would be to carry on a horse-and-buggy method and would result in waste that no real business, such as that of rendering water service, could possibly withstand.

In some cities, when the subject of metering is brought up, objections are raised and the idea is abandoned. As a result, instead of spending a reasonable sum for meters, large treatment plants are installed and source-of-supply works are increased. In a few years a shortage again occurs, the same dispute takes place and the waste goes on and on.

The necessity for conservation of the water supply is constantly in the news. Nearly every section of the country has had its experience with a water shortage recently, and some are undergoing it now. The surest way to conserve water is to meter it, so that everyone pays for what he uses. The multiple-unit dwelling should be no exception.

William G. Banks

Div. Engr., Div. of Water, Dept. of Public Works, Newark, N.J.

Aside from fire lines, all consumers' water service connections to the general-purpose supply system in Newark are required to be and are, with minor exceptions, metered.

Normally, apartment and multiple-dwelling owners in Newark do not have trouble with wasteful tenants, although there are, of course, exceptions from time to time. It is the author's opinion that owner-tenant relations are the determining factor, and it is not believed that the average person will deliberately waste water. The author knows of no special rent arrangement in effect in Newark by means of which owners pass on to tenants, on a pro rata basis, the cost of excessive water use.

Some owners of apartment and multiple dwellings claim that, if metering were adopted, their tenants would not cooperate and water would be wasted, with resultant high water bills. This argument implies that water waste now exists under the flat-rate system and that metering would result in materially increased charges for water consumed. Now that everyone in the New York metropolitan area is water conscious, a simple educational campaign would appear sufficient to obtain the cooperation of tenants.

John C. Detweiler

Mgr., Dept. of Water Operation, Metropolitan Utilities Dist., Omaha, Neb.

Distributing the cost of water supplied to multiple dwellings is a part of the overall water-metering problem.

Customers of the Omaha, Neb., water system, operated by the Metropolitan Utilities Dist. of Omaha, are practically 100 per cent metered. It is common practice, however, for apartment house operators to furnish water to individual apartments without submetering or making any charge for water used. This situation does not prevent waste of water since the ultimate consumer does not directly share in the cost. The relationship between the landlord and tenant is an important factor. A good tenant will try to prevent waste and report leaky fixtures, while the reverse may be true if tenant-landlord relations are poor.

It can be said that most apartment house operators attempt to keep plumbing fixtures in good condition. Inattention to the proper closure of fixtures, however, is often the source of trouble where water consumption figures are high.

The installation of water meters in multiple dwellings will, at least, make known the amount used, and, if the consumption per unit is out of line, the operator or owner of the property (whoever pays the water bill) should take steps to reduce water wastage by stopping leaks and encouraging conservation of water by the tenants.

The installation of small air-conditioning units which use water in the cooling process may add to the problem, and it would appear practical to levy a flat-rate charge on such equipment during the summer months. Where larger air-conditioning units are involved, submetering might pay.

The average monthly water consumption figures (Table 1) for two government-operated housing projects, and one privately operated apartment group in Omaha may be of interest.

TABLE 1

Average Monthly Water Use in Apartments, 1949

Project	No. of Units	Size of Apartments	Avg. Monthly Water Use per Apartment cu.ft.	Avg. Monthly Water Cost per Apartment $
Public				
South Side	522	3½–6½ rooms	640	0.51
North Side	556	3½–6½ rooms	700	0.58
Private	400	1–3 rooms; "efficiency apartments"	424	0.40

B. E. Payne

Chief Engr. & Supt., Louisville Water Co., Louisville, Ky.

The practice in Louisville, Ky., is to meter apartments and multiple dwellings where the service enters the building.

It is the author's opinion that, if the apartment owner maintains the fixtures properly, he will have little trouble with water wastage by his tenants. The largest per capita consumption is found in poorly maintained buildings. For example, pipes improperly protected against freezing cause tenants

to allow water to run in cold weather to avoid a possible stoppage of supply.

To the author's knowledge, there is no special charge made to tenants for excessive use of water, although some owners submeter certain parts of their buildings to determine how much of the overall water bill should be apportioned to refrigeration and air conditioning. Water is so cheap, however, that it seldom is worth while to make the piping changes necessary for submetering.

The Louisville Water Co. reads and bills on a bimonthly schedule. Some apartment owners and agents have asked for monthly readings and billing in order to keep a better check on plumbing conditions, but only two or three were willing to pay a charge of 20¢ per extra reading and billing on a monthly basis.

Since Louisville has a sewer service charge of 50 per cent of the metered water cost, wasted water is actually paid for one and one-half times.

The author sees no reason why the water utility should be the inspector of an apartment owner's plumbing. Moreover, installing individual apartment meters would usually involve too great a cost to either the owner or the utility. No effective way of charging a tenant extra for wasting water has been found. If the metered water bill turns out to be greatly in excess of the old flat-rate charge, an increase in rents might be in order.

The Louisville Water Co. went through these difficulties in 1939 and 1940 when it adopted 100 per cent metering. The owners have become reconciled to the fact that water and sewer service must be paid for. The only complaint now seems to be that the company does not read and bill often enough to keep the cost of leaks low.

George J. Van Dorp

Comr., Div. of Water, Dept. of Public Services, Toledo, Ohio

In discussing metering for multiple dwellings, consideration must be given both to the economy of the method and to its equity with regard to the customer and the utility. The payment made to the utility must cover, in addition to the cost of producing and distributing the water, such items as meter reading, billing and collecting, accounting, and often the investment in and maintenance of meters. All of these expenses vary greatly in proportion to the amount of water consumed under the various accounts, being much greater for the small domestic consumer than for the large industrial user. Consequently, it may be well, at the outset, to analyze the types of consumers and thus properly identify what should be termed a multiple-dwelling unit. Strictly speaking, any building housing more than one family is a multiple dwelling, yet such a broad classification is not generally adopted.

The smallest residential customer is the single-family dwelling, which, depending on the location, number and activity of the occupants, may employ a $\frac{5}{8}$-, $\frac{3}{4}$- or 1-in. meter. Next come the two- and four-family apartments and small rooming houses. These also are usually served by $\frac{5}{8}$–1-in. meters. Multiple-dwelling units, then, will include the larger rooming houses, apartment buildings, the newer type of multiple-housing units containing six to ten full-size family apartments, and hotels. This type will usually require a meter ranging from $1\frac{1}{2}$ or 2 in. for the smaller units up to perhaps 6 or 8 in. for the larger hotels.

In Toledo, Ohio, the water division furnishes and maintains, free of charge, all meters of 1-in. nominal size or less.

All larger meters are of the compound type, as specified by the Div. of Water, and must be purchased by the customer, who also pays for all repairs and necessary replacements or additions to the metering equipment. With the exception of water for municipal buildings and other public usage, such as swimming pools or fire protection, Toledo is 100 per cent metered.

The consumption of all multiple dwellings as defined above is measured through one meter located in each building. Since the Toledo water rate schedule has a minimum charge and is graduated in steps which provide for lower charges as consumption increases, the multiple-dwelling accounts with a larger consumption obtain the benefit of the lower rate bracket. The charge will seldom, if ever, reach an amount equal to the minimum bill times the number of families occupying the building. This practice is justifiable because of the reduced cost to the Div. of Water in the matter of meters, meter reading, billing and accounting.

The utility sometimes receives complaints of high water charges from the owner or operator of a multiple dwelling. If, after investigation, the high consumption of water is confirmed, the operator is advised to present his case to the tenants, since the utility has no control over their actions or habits. Recently owners of multiple-housing units have been granted the option of installing separate meters in each apartment within the unit or of using one meter for all service. Where separate meters are used for each apartment, the building is served through one or more connections, each terminating in a header within the building, to which the separate meters are connected through a lock type valve controlling every meter inlet. It is understood that, if separate meters are used, each is to become an individual water account, subject to the minimum billing.

With separate metering, the owner is able to employ a smaller meter furnished free of charge and is in a position to have each tenant pay and be responsible for his own water charge. Recently one builder of 72 multiple dwellings, each providing for seven families, thought well of this plan but, upon investigation, found that the increased cost of plumbing necessary to isolate the water service to each apartment was excessive in view of the small saving possible under the existing low water rates. On the other hand, a builder of 40 multiple-housing units for 480 families intends to install individual meters for each apartment. The author believes that the separate-metering plan is worthy of consideration where water rates are high enough to make substantial savings possible.

Toledo's one great difficulty has been in supplying ⅝–1-in. meters free of charge. Many customers, usually on the advice of their plumber, and because it does not cost them anything, demand the installation of a 1-in. meter regardless of their need. It is often difficult to convince them that a smaller meter will serve as well, especially if they have experienced low pressures due to excessive friction in an old or inadequate service connection or in their plumbing. In such situations, it is necessary for the department to conduct flow tests of the house service, by means of special flow meters and pressure gages, to prove to the customer that his own facilities are at fault.

These unfair demands for meters of excessive size can, it is believed, be eliminated by including in the water rate a schedule of service charges which will vary with the size of the meter. This provision will be made in the new rate schedule being prepared.

Recording Customer Use of Water

By E. Arthur Bell and Edward Walasyk

A joint discussion presented on May 22, 1950, at the Annual Conference, Philadelphia, by E. Arthur Bell, Water Supt., Essex Fells, N.J., and Edward Walasyk, Distr. Engr., Hackensack Water Co., Weehawken, N.J.

Residential Community Use—*E. Arthur Bell*

ESSEX Fells, a residential community in northern New Jersey, has a water system serving a population of approximately 30,000. The lion's share—93 per cent—of the water pumped from the system's twelve wells is sold wholesale to neighboring towns. The remaining 7 per cent is distributed to Essex Fells residents through approximately 400 metered services.

From time to time the department had been troubled by high-bill complaints from customers who insisted that the water meter rather than their own plumbing was at fault, despite test results to the contrary. Finally, in April 1939, to placate a particularly obstreperous customer, a Brainard "Meter Master" * was borrowed from the Ridgewood, N.J., water department and installed on the customer's premises. Even then, it took five days to convince him that his difficulties stemmed from a leaky toilet. In fact, he never did apologize, but he stopped complaining.

Finding it somewhat hard to justify the purchase of a Meter Master for a utility with less than 400 metered services, it was deemed prudent to install the borrowed instrument at the home of the mayor. As a result, a leakage of more than 1,000 gal. was detected in a 24-hour period. A broken pipe leading to a small greenhouse adjacent to the mayor's house was the offender, with no water visible above the ground. Shortly thereafter the Essex Fells water department became the proud possessor of a shiny new Meter Master.

Chronic complainers were educated in a relatively short time, leaving the instrument to become just another "dust catcher." Early in 1940, however, having a regularly employed utility man with sufficient spare time on his hands, it was decided to use the device to check every home in the community.

This program was inaugurated on January 23, 1940, and continued until completed on September 30, 1941. No records were made on Saturdays, Sundays or during the vacation periods of the utility man, who conducted the entire survey. The results were quite amazing—there were 342 routine installations, and leaks were discovered in 104 homes, or 30.4 per cent of the total. These leaks range from 1 to 1,320 gpd., distributed as shown in Table 1.

The total leakage observed was 10,800 gpd. or 3,942,000 gal. annually, which represented 11.3 per cent of the

* This device is described on pp. 927–30, this issue.—*Ed.*

entire water use of the municipality. The yearly saving to the utility's customers was approximately $1,600, and the good will received from this program is above calculation.

Some observations on the pattern of water use found are in order. In a residential community, the demand appears fairly constant, with the exception of that for lawn sprinkling. Most of the meters installed were of the proper size, but, in a few locations, it was necessary to change to a larger one, and about 35 meters, or 10 per cent, were shown to be too large. The daily use of water in every home—exclusive of leakage—is given in Table 2.

TABLE 1

Residential Leakage

Amount of Leakage *gpd.*	No. of Homes
1–10	8
10–25	37
25–50	9
50–100	19
100–250	22
250–500	6
500–1,000	1
over 1,000	2
Total	104

From this table, it can be computed that 85.7 per cent of the use lay between 50 and 400 gpd. The peak flows were not abnormal. It should be noted that the static pressures in the system are relatively high, ranging from 100 to 150 psi. in most areas, and it is possible to install meters on the small side without unduly low residual pressures.

Value of Meter Master

The Meter Master has been loaned to nearby communities to aid them in resolving complaints. Its use was so successful that the Borough of Verona, with 2,650 customers, purchased one for itself. At present Essex Fells does not employ it regularly, but a quarterly analysis is made of all water bills, and the Meter Master is installed at any home where the consumption is unusually large. Only recently five sizable leaks were recorded and corrected.

TABLE 2

Residential Water Use

Water Use *gpd.*	No. of Homes
25–50	12
51–100	51
101–150	42
151–200	67
201–250	46
251–300	46
301–350	27
351–400	14
401–450	7
451–500	8
501–550	3
551–600	2
601–650	4
651–700	1
701–750	2
751–800	2
801–900	2
901–1,000	1
1,070	1
1,230	1
1,300	1
1,710	1
1,800	1

The customers are gratified by the service rendered, and complaints are infrequent, as abnormal use is checked before presenting the bill.

A chart record of customers' use and loss of water is valuable in many ways. It provides data for proper meter installation, indicates leaks when present —thus promoting water conservation —and, finally, makes for excellent public relations.

Apartment Building Use—*Edward Walasyk*

One of the perennial problems of the water department superintendent or engineer is to determine the proper and adequate size of service and meter for multiple-family apartment buildings. In order for this to be done effectively and intelligently, data regarding rates of flows in such buildings are essential.

In 1939 the Hackensack Water Co. of New Jersey started a program to obtain the "range of flow" in apartment buildings. During the war years the study was discontinued. With the purchase of two Brainard strip chart "Meter Masters" * in the latter part of 1949, it was decided to continue the study so that a rational approach could be made to the meter and service sizing problems which were being introduced by the recent construction of "garden" type apartment buildings in the company territory.

The main purpose of the study was to find the correlation between maximum and minimum rates of flow and the number of apartments in the building. This information could be used as a basis for making recommendations to architects and plumbers in the design of service and connecting piping. At present most architects employ either some arbitrary "percentage of total fixture capacity" or the National Bureau of Standards method which derives maximum rate of flow by applying the theory of probability to the number and type of fixtures in a building. In this study, no attempt was made to obtain pressure losses in the service line, connecting piping or meter and interior building piping, nor was residual pressure on the top floors of buildings investigated.

* For a description of this device and the manner of its use in the Hackensack system studies, see pp. 927–30, this issue.—*Ed.*

Description of System

The Hackensack Water Co. supplies 53 municipalities with a total population of about 500,000 in Hudson and Bergen Counties, located in the northeastern portion of New Jersey. The area served is roughly a $7\frac{1}{2} \times 18$-mile rectangle, with elevations ranging from zero to 500 ft. above mean sea level. The distribution system pressures vary from 30 to 150 psi., with the greater portion in the 50–110-psi. range. After purification all water is delivered by pumping to the distribution system, which consists of approximately 1,100 miles of pipe, from 4 to 54 in. in diameter. The quantity delivered to distribution in 1949 was 45.1 mgd.

The system is 100 per cent metered, with 94,623 active connections, 91,356 having either $\frac{5}{8}$- or $\frac{3}{4}$-in. meters and the remaining 3,267, 1- to 12-in. The ratio of "service meter registration" to "total water to distribution system" is considered "water accounted for" and averages 86.5 per cent.

Under New Jersey Public Utility Commission rules and regulations governing private water utilities, the utility installs and owns the service from the main to the curb, terminating with a curb stop. The meter is also owned by the utility, while the connecting pipe from the curb stop into the customer's property is installed and owned by the customer.

It is the practice to treat individually each request for water service to apartment buildings. The size of meter and service (usually the same) is based on five factors: [1] the static street main pressure available; [2] the number of apartments in the building and the type of fixtures (flush tank or flush valve water closets); [3] the height of

the building; [4] the meter loss; and [5] the length of the service and connecting pipe.

Procedure

Three Brainard Meter Masters were used in obtaining rates of flow indicated by service meters of the current and positive-displacement types. Daily maximum rates of flow were obtained for periods of ¼, ½, 1, 2 and 5 minutes. The ¼-minute interval was used as a practical "instantaneous period of time" for obtaining the maximum rate of flow. This interval allowed for the overlapping of flush valve operations, which normally take six to eight seconds. The five-minute period was used to determine the maximum sustained rate of flow.

At present 85 apartment building investigations have been completed (24- to 72-hour records). These buildings have either flush valve or flush tank water closets, contain from 6 to 126 apartments and are 2 to 5 stories in height. The static street main pressures vary from 50 to 110 psi.; the length of service and connecting pipe, from 10 to 100 ft.; and the service and meter size, from 1 to 4 in. (buildings with -in. services and meters have fire hose bibs connected throughout).

The maximum rates of flow obtained are all based on a daily high which is undoubtedly less than the monthly or annual daily maximum. The company has planned to resurvey a selected group of these apartment buildings during the summer months to determine whether there is any change in the general flow pattern and in the range of flows.

The buildings investigated were divided into two groups, those having flush tank and those having flush valve water closets. The author believes that the maximum rate of flow based on the number of apartments in the building is of more practical value than if computed on a "total fixture capacity" basis. No two authorities seem to agree on rates of flow in plumbing fixtures, whereas, in modern apartment buildings, the unit apartment rate of demand depends primarily on the type of water closet fixture used. The usual fixtures found in each apartment are a combination sink and wash tub in the kitchen and a tub, shower, wash basin and water closet in the bathroom. The standard laundry equipment in almost all new apartment buildings consists of two automatic washing machines and two laundry trays.

Results of Study

Table 1 shows the relation of the actual maximum rates of flow to the number of apartments in the building, based on a study of 35 buildings (6–126 apartments) having flush valve water closets and 50 buildings (14–70 apartments) having flush tank water closets. Practically all of the investigations were made during the winter or spring.

Because of time limitations, it was impossible to obtain the percentage of time at which various rates of flow prevailed during 24-hour periods in the buildings investigated. An inspection of the chart records obtained indicated that a 32-family apartment building in Maywood, N.J., showed a typical flow pattern. The average monthly consumption per apartment was approximately normal. (The average in Hackensack Water Co. territory is 700 cu.ft. per apartment per month.) The indicated night rate of flow, from 2 to 5 A.M., for this size of building was

about the average found during the study. The 24-hour period included a portion of Sunday and Monday, giving a composite picture of the workday and holiday water demands.

This two-year-old building was two stories high and contained 32 3½–4½-room apartments, all occupied. The tenants comprised 64 adults and 24 children. The average monthly consumption in the building was 22,000 cu.ft. (165,000 gal.), or 690 cu.ft. (5,200 gal.) per apartment per month. Water was supplied from a 6-in. street main, with 100-psi. pressure, through 9 ft. of 1½-in. copper service pipe and 40 ft. of 1½-in. copper connecting pipe. A 1½-in. disk type meter was located in the basement. The building had a total of 302 water fixtures—3 in the boiler room, 3 garden hose bibs, 8 in the basement laundry (2 washing machines and 2 trays) and 9 in each apartment (a combination sink with 2 faucets, in the kitchen; a tub, shower and wash basin, each with 2 faucets, and a wall tank water closet, in the bathroom).

Table 2 shows the hourly consumption in cubic feet and gallons, and summarizes the rate-of-flow data found.

TABLE 1

Relation of Flow Rate to Number of Apartments

No. of Apartments in Building	Type of Water Closets in Building									
	Flush Valve					Flush Tank				
	Time—*min.*									
	¼	½	1	2	5	¼	½	1	2	5
	Flow Rate—*gpm.*									
10	65	38	18	15	13	33	27	17	15	12
20	78	50	27	21	18	42	36	26	21	16
30	87	58	35	27	22	50	44	33	27	20
40	95	66	42	32	25	58	52	40	32	24
50	102	73	49	37	28	65	58	47	37	27
60	107	78	55	43	31	72	63	53	41	30
70	112	83	61	48	33	76	68	58	45	33
80	117	88	66	53	35					
90	122	93	72	57	38					
100	126	97	77	61	40					
110	130	102	82	65	42					
120	134	107	87	68	44					
130	138	112	92	71	46					

Table 3 was obtained by using a minimum period of ½ minute in determining rates of flow. It shows the amount registered in cubic feet and gallons and the percentage of total registration between the indicated flow limits.

The Meter Master record shows that 8.3 per cent of all the water registered during the 24-hour period was below the 1.5-gpm. rate and that during 435 minutes, or 30 per cent of the

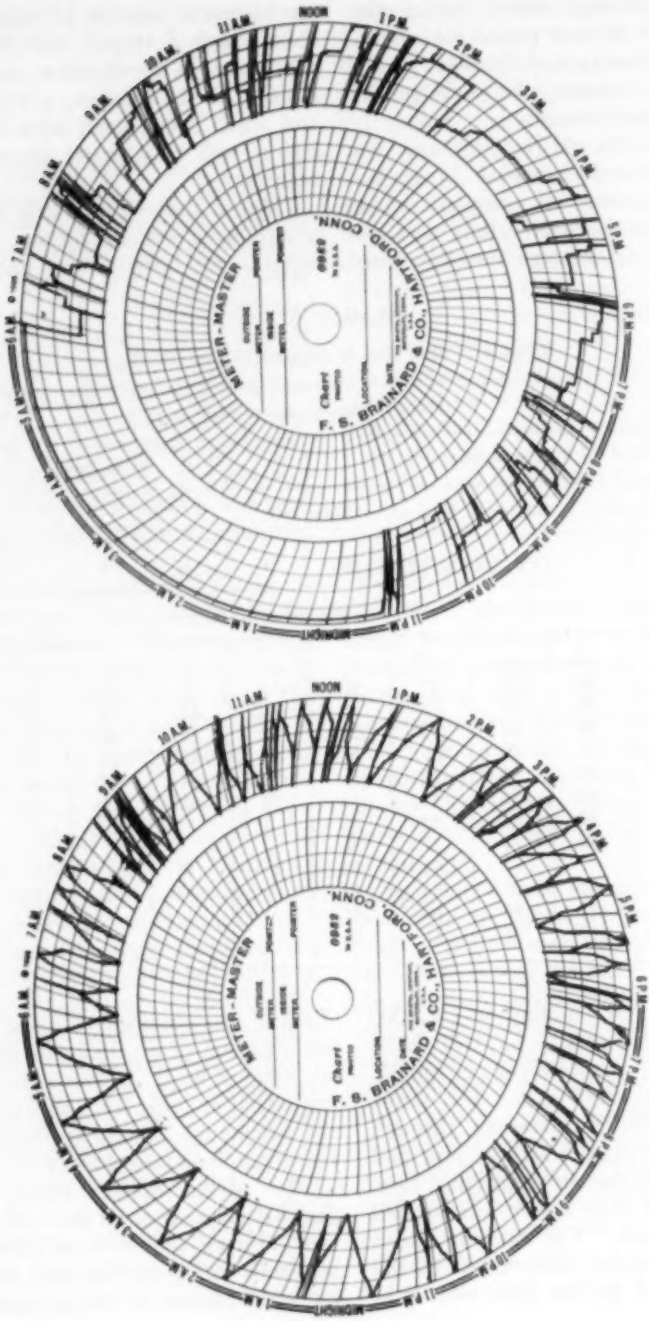

Fig. 1-2. Meter Master Circular Chart Records

TABLE 2

Consumption and Flow Rate Data

Time	Hourly Use	
	cu. ft.	*gal.*
Sunday, March 26, 1950		
10–11 A.M.	59	441
11–12	54	404
12–1 P.M.	48	359
1–2	30	224
2–3	34	254
3–4	31	232
4–5	33	247
5–6	18	135
6–7	43	322
7–8	25	187
8–9	20	150
9–10	28	209
10–11	34	254
11–12	25	187
Monday, March 27, 1950		
12–1 A.M.	25	187
1–2	5	37
2–3	2	15
3–4	2	15
4–5	3	22
5–6	1	9
6–7	32	239
7–8	71	531
8–9	40	299
9–10	35	262
	24-hr. Use	
Total	698	5,221
Per apartment		163
Per person		59

Demand	Period	*gpm.*
Average	24 hr.	3.6
Average	daytime*	4.6
Average	night†	0.8
Minimum	2–5 A.M.	0.16
Maximum	¼ min.‡	48
Maximum	½ min.	38
Maximum	1 min.	26
Maximum	2 min.	21
Maximum	5 min.	17
Maximum	1 hr.§	9

* 6 A.M. to midnight.
† Midnight to 6 A.M.
‡ 7:03 A.M.
§ 7–8 P.M.

time, the rate of flow was below 0.5 gpm.

Some interesting facts were observed in this study:

1. On weekdays there were two distinct peak hourly periods: 7–8 A.M. and 7–8 P.M. The ¼-minute maximum rate of flow practically always occurred during the morning peak hour. The evening peak period showed a sustained, moderate rate of flow.

2. On Saturday and Sunday only one peak period was observed, usually before noon.

3. Daily consumption of water remained approximately constant throughout the week.

TABLE 3

Flow Rate Pattern

Flow Rate *gpm.*	Amount Registered		Per Cent of Total Registration
	cu. ft.	*gal.*	
0–½	16.2	121	2.3
½–1½	42.1	315	6.0
1½–5	140.8	1,053	20.2
5–10	207.6	1,553	29.8
10–25	280.5	2,098	40.2
25–50	10.8	81	1.5
Total	698.0	5,221	100.0

4. Almost all new apartment buildings in the Hackensack Water Co. territory use flush tank water closets.

5. In buildings having more than 20 apartments, service meters showed a continuous registration of 0.1 ± to 0.6 ± gpm. during the three-hour period from 2 to 5 A.M. This is considered to be due to cumulative fixture leakage in the building. The condition was present in spite of an intensive drive in the New York metropolitan area during the latter part of 1949 and early 1950 to stop wastage of water by repairing all leaking fixtures.

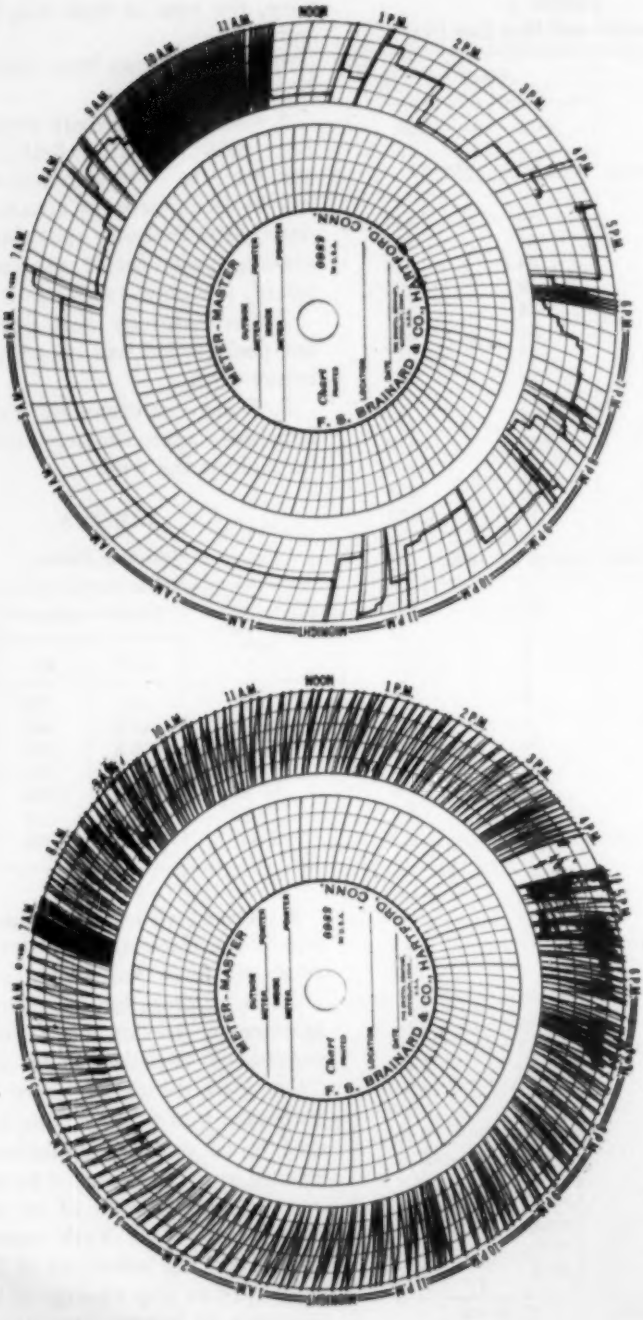

Fig. 3-4. Meter Master Circular Chart Records

Meter Master—*E. Arthur Bell and Edward Walasyk*

The Brainard "Rate-of-Flow Register" or "Meter Master" * is operated by a spring clock mechanism, which is so regulated that a round chart can make a complete revolution in 6, 24 or 72 hours and a strip chart can operate at six speeds.

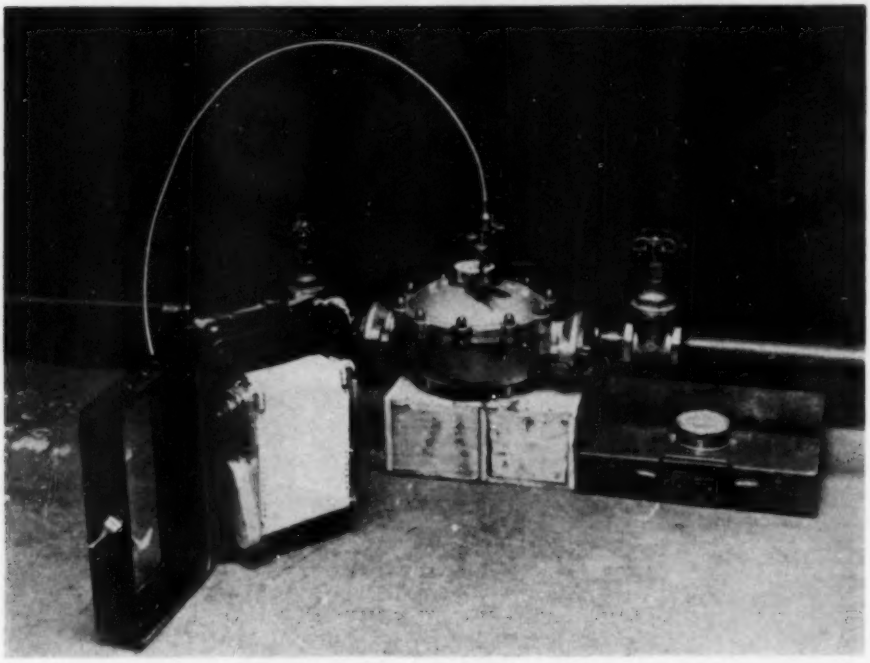

FIG. 5. Single-Pen Strip Chart Unit

Essex Fells Equipment

Essex Fells uses the round chart (8 in. in diameter), geared for 6 or 24 hours. There are two concentric, circular graphs on the chart, so that the registration of either a single-dial or a compound meter can be recorded. Traversing each graph is a pen actuated by a flexible cable connected to the test dial of the meter. Each complete revolution of the test dial causes the pen to make a vertical line on the graph from the bottom to the top and back. Horizontal motion is achieved by the rotation of the chart under the pen, the latter having only vertical motion. The recording mechanism is inclosed in a hinged, steel cabinet, with a lock to prevent tampering. Approximately fifteen minutes is required to install or remove the device.

Figures 1–4 illustrate the charts used at Essex Fells. Each complete stroke of the pen (from the inner to the outer circle and back) represents 10 gal. of water use. A concentric, or horizontal, inkline (for example, in Fig. 2, be-

* A trade name of F. S. Brainard and Co., Hartford, Conn.

tween approximately 11:17 P.M. and 6:07 A.M., between 6:08 A.M. and 6:30 A.M., and so forth) indicates that no water is being used. The continuous (24-hour) use of water shown on the chart in Fig. 1 implies the presence of a leak. Since approximately 10 gph. is recorded between 1 and 6 A.M., which cannot be ascribed to normal residential use, this rate of leakage may be assumed for the entire 24-hour period, giving an estimated loss of 240 gpd. This is a considerable amount, as the total daily consumption calculated from the chart is only 550 gal. Regular leakage on the order of 10 gph. is likely to be due to a faulty toilet. In this instance, such a defect was actually found. Figure 2 is a chart of a test at the same residence after the toilet had been fixed. As mentioned above, no water use is shown during the night, and the total daily consumption is down to 400 gal.

The chart in Fig. 3 is evidence that a serious leak exists at the house where the test was made. Between midnight and 6 A.M. abnormal water use at the rate of about 55 gph. is recorded, implying a 24-hour leakage of approximately 1,320 gal. Such an amount is indicative of a broken pipe, which was, in fact, discovered upon investigation. On the other hand, the intensive use of water between 9 and 11 A.M. shown on the chart in Fig. 4 is not the result of a permanent defect, since no abnormal night use is recorded. It may

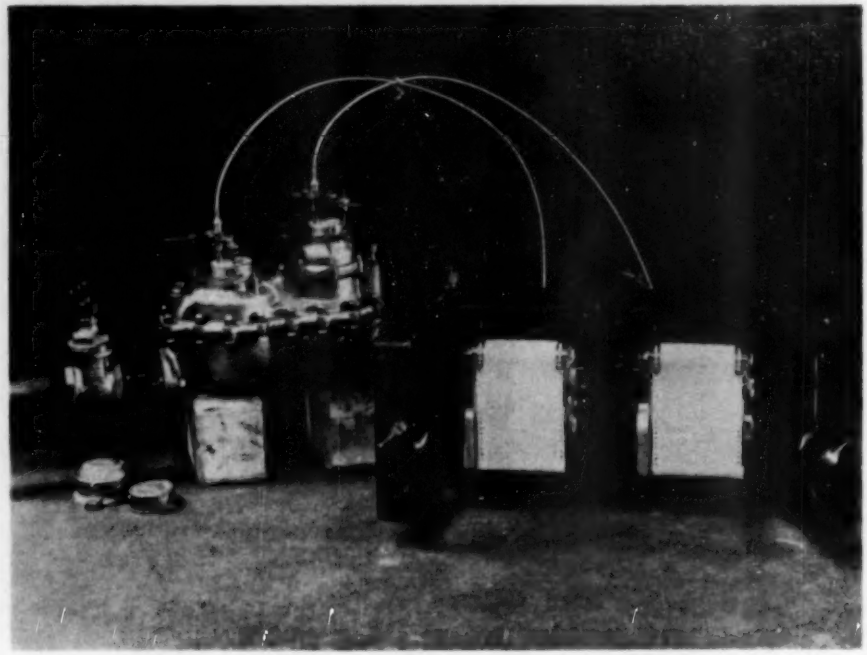

FIG. 6. Two-Pen Strip Chart Unit

have been due to lawn sprinkling or, perhaps, to a temporary plumbing failure such as a stuck float.

The Meter Master charts not only disclose the presence of leakage but also provide a picture of the water use —and, therefore, of the habits of the occupants—in the residence tested. Taking Fig. 2 as an illustration, the first water use (about 4 gal.) in the morning occurred shortly after 6 A.M. the two younger children retired between 8 and 9 P.M., the older ones at 9:30 and 10, and the parents at a little after 11.

Although the preceding description makes no claim to complete accuracy, it does generally fit the pattern of water use recorded on the chart in question. Had there been a substantial amount of use, particularly in the early morning hours, which could not be

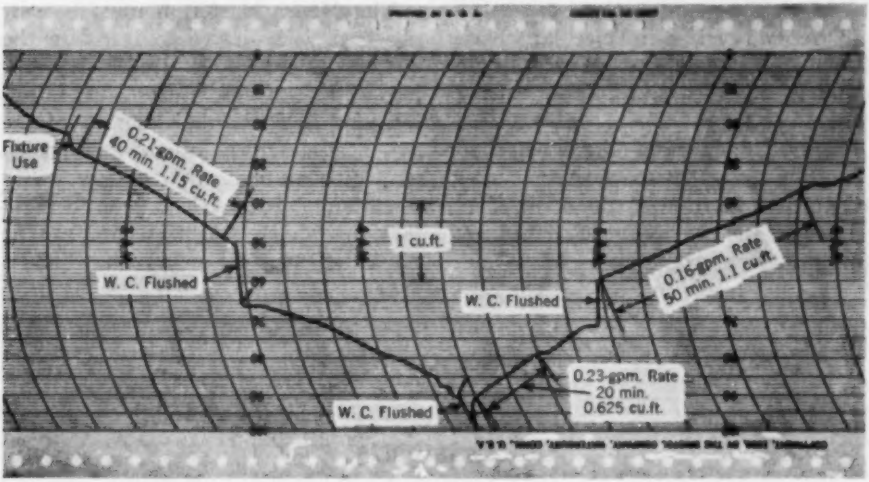

FIG. 7. Strip Chart Record

This was probably a toilet flush, which averages 4–5 gal. Soon afterward the entire family, consisting of two adults and four children of various ages, arose and got ready for the day. The increased water use around 8 A.M. indicates that the shower might have been on and also that breakfast was being prepared. Dishwashing took place after 9 A.M., and possibly the noon meal was cooked about 11 A.M., the luncheon dishes being done around 1 P.M. Dinner was evidently prepared between 5 and 6 P.M. Presumably, explained reasonably in terms of the occupants' activities, a leak might well have been suspected.

Hackensack Equipment

In the Hackensack Water Co. studies, three types of Meter Masters were used:

1. A single-pen, strip chart unit (90-ft. roll), driven by a spring clock and equipped with a quick-change chart-speed lever having three positions—off, inches per hour (iph.) and inches per minute (ipm.). The unit was furnished

with change gears to give a range of chart speeds from ¾ ipm. or iph. to 12 ipm. or iph. The chart is 4¾ in. wide, with 100 divisions. The normal chart time ruling was 3 iph., with ten-minute subdivisions.

2. A two-pen, strip chart unit, with two 90-ft. roll charts, driven by a single spring clock having the same speed ranges as the single-pen unit. The chart drives were solidly coupled so that synchronous readings could be obtained on compound meters.

3. A two-pen, 8-in. circular chart, driven by interchangeable 15-minute and 1-hour, or 6- and 24-hour spring clocks.

Figure 5 shows a single-pen and Fig. 6 a two-pen strip chart Meter Master. A portion of the strip chart record for the previously described 32-family apartment building in Maywood, N.J., is illustrated in Fig. 7. The captions on the chart indicate the manner in which the record is interpreted.

It was found that a 12-iph. chart speed, with spot checks made at 3 or 6 ipm. to facilitate obtaining maximum rates of flow, gave records which could be easily interpreted. The 10-ft. dial was used on meters having circular registers. On straight-reading registers having a 1-ft. dial, a 10:1 reducer was used to give an equivalent 10-ft. dial reading.

The Meter Master, it must be emphasized, is a device to translate the quantity of water measured by a meter into a "rate-of-flow" record and is not intended to check the accuracy of the meter, although the rate-of-flow record may give an indication of low meter sensitivity. It is well to keep in mind that the Meter Master record can be no better than the meter on which it is set.

Erratum

In the paper "Production Cost Increases," by Robert W. Williamson, which appeared in the August 1950 JOURNAL (Vol. 42, p. 797), the caption for Table 1 is incorrect. The present caption, supplied by the editors, reads: "Cost of Chemicals for 1,000 gal." It should have read: "Cost per Pound of Chemicals." Thus, the cost figures given in the table do not refer to the expense of the chemicals required to produce 1,000 gal. of water, but to the price per pound of the chemicals themselves.

Design of Steel Ring Flanges for Water Works Service—A Progress Report

By Russell E. Barnard

A paper presented on May 24, 1950, at the Annual Conference, Philadelphia, by Russell E. Barnard, Chairman, Technical Standards Committee of the Steel Water Pipe Manufacturers Technical Advisory Committee; Member, Joint A.W.W.A.-A.S.M.E. Committee on Standard Dimensions of Flanges for Steel Water Pipe; and Advisory Engr., Welded Pipe Sales Div., Armco Drainage & Metal Products, Inc., Middletown, Ohio.

IN 1942 the Technical Standards Committee of the Steel Water Pipe Manufacturers Technical Advisory Committee undertook to establish a standard for steel ring flanges used on welded steel water pipe. As a part of this effort, a paper (1) on the subject was printed in the JOURNAL in September 1944. Following this publication, a joint committee, composed of representatives of the American Water Works Assn. and the American Society of Mechanical Engineers, was formed to make the design of the flanges a joint effort so that the full experience of both organizations could be had in the development. This paper is a progress report on the work of a subcommittee of that joint committee charged with developing design procedure.

The A.W.W.A. sponsored this work because a need existed for a set of flange standards for water pressures lower than 230 psi. in all sizes and diameters larger than 24 in., which is the upper diameter limit of existing A.S.A. standards. Also, it was felt that, if the undertaking were limited to the use of soft cloth-inserted rubber gaskets and carbon-steel bolting, greater economy could be achieved as compared with designs based on a wider range of application.

Most water pipe services operate at pressures of 75–150 psi. and at temperatures below 100°F. The flanges ordinarily specified for these conditions are of forged steel, having dimensions corresponding to American Standard B16e–1939 (2). This is true up to the 24-in. diameter size, beyond which only commercial standards are available.

The maximum, nonshock pressure rating for 150-lb. American Standard flanges (230 psi. at 100°F.) is higher than is actually required for many water pipe installations. This would imply that the flanges used at present are overdesigned for such application and that thinner flanges would be adequate, economical and desirable. Such a flange made in the form of a simple, hubless ring of steel slipped over the end of a steel pipe and securely welded to the pipe barrel at the front and back edge, designed differently by many individuals, has been used successfully for several decades.

An investigation was made in 1945 by Harry LaTour, Sr. Testing Engr., Research Labs., Armco Steel Corp., Middletown, Ohio, to obtain stress data on such flanges in action, to check the existing methods of design and to develop a practical method of designing the flanges using the data obtained. The data and conclusions developed in that investigation serve in part as a basis for this report. Confirmatory tests were made at a later date under the direction of Frank S. G. Williams, Taylor Forge and Pipe Works, New York.

To secure data which would be helpful in establishing a suitable basis for the design of ring flanges, a 6-in., 12-in. and 36-in. flanged joint were each subjected to bolt load and hydrostatic pressure.

The outside diameter, drilling template and bolt diameter of the test specimens were those of the 125-lb. American Standard cast-iron flanges. The thickness of flanges was less.

It is important to note that all the gaskets used were $\frac{1}{16}$ in. thick, soft rubber, cloth-inserted, and were part-face—that is, they occupied the annular space between the inside of the bolts and the outside diameter of the pipe. This is the kind of gasket ordinarily used in the water works field.

A drawing of the 12-in. diameter ring flange joint test specimen is shown in Fig. 1. The other flanged joints were of similar design except for the size of parts.

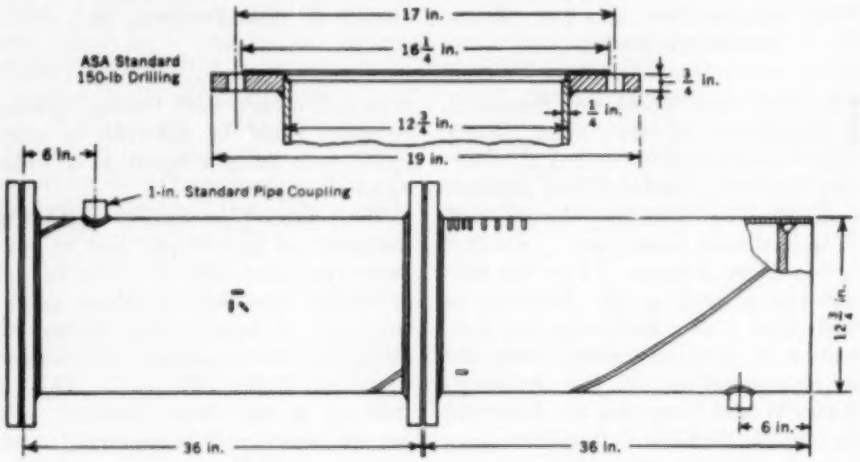

FIG. 1. Ring Flange Joint Test Specimen

An electric resistance type of strain gage * was used to determine the strains in chosen locations. The following strains were measured: [1] bolt strains, [2] radial and circumferential strains on the outside weld fillet, [3] radial and circumferential strains on the outside surface of the ring flange near the outside weld fillet, [4] circumferential strains on the outside

* SR-4 Strain Gage, made by Baldwin Southwark Div., Baldwin Locomotive Works, Philadelphia.

of the ring flange between bolts on the bolt circle, [5] circumferential and axial strains on the pipe wall at various locations adjoining the ring flange and [6] axial and circumferential strains on the pipe wall at a location unaffected by flange stresses. Two of the test setups are shown in Fig. 2 and 3.

Briefly, the test procedure consisted of: [1] establishing zero-point strain readings before bolting, [2] having a skilled pipe fitter tighten the bolts as he would ordinarily do, [3] taking readings, [4] filling with water at room temperature, [5] applying an increment of pressure and taking readings, [6] applying a second increment of pressure and taking readings, [7] continuing to apply increments and taking readings until leakage occurred, and [8] releasing pressure and taking readings.

The maximum test pressures successfully imposed on the three sizes of pipe tested are given in Table 1.

TABLE 1

Hydrostatic Pressure Test Data

Outside Diam. of Pipe *in.*	Pipe Wall Thickness *in.*	Flange Thickness *in.*	No. of Bolts	Diam. of Bolts *in.*	Design Pressure *psi.*	Maximum Test Pressure Without Leakage *psi.*
6⅝	0.188	0.42	8	¾	150	400*
12¾	0.250	0.68	12	¾	150	350†
36	0.500	2	32	1¼	150	250‡

* One of three tests showed seep leakage at 400 psi. The other two tests on the same specimen showed no leakage at 500 psi.

† Slight leakage occurred at 400 psi. Gasket blew at 420 psi.

‡ These test sections were taken from a production order. They were subjected to a maximum test of 250 psi. and not carried higher to force leakage. These same flanges were later assembled in the field installation, using full-face paper gaskets of drawing-paper thickness. There was no leakage either in the experimental test using the part-face rubber gasket or in the field installation using the paper gasket.

Conclusions From Tests

A few of the more important conclusions drawn from test data interpretation are:

1. That the slip-on type steel ring flange welded to the pipe at front and back acts as an integral flange.

2. That strains in the pipe wall follow the rules of combined strains in a biaxial field and may be great enough to be in the region of plastic strain.

3. That the preliminary bolt tightening materially affects the direction and magnitude of the strains in various parts of the flange and in the pipe wall near the flange.

4. That the major parts of the strains in the weld fillet are due to the initial bolt tightening.

5. That the bolt load decreases as the hydrostatic pressure is applied.

6. That when the bolt load again shows an increase under increasing hydrostatic pressure, gasket leakage occurs.

7. That stresses in the bolts after tightening are of yield-point magnitude.

8. That the primary aim in flange design should be to prevent joint leakage, since steel flange joints do not fail by fracture.

9. That the bolt loads employed in design should be those actually encountered in the field when the me-

chanic tightens the bolts using the customary procedure and rules.

10. That the design itself should tie in satisfactorily with sound theory, with the test results and with the satisfactory field performance of lightweight flanges which have been in use for many years.

New Concept of Flange Design

When the test results were analyzed, it became obvious that the design formulas used in establishing American Standard flange dimensions predicted fantastically high localized stresses even when the joint assembly performed satisfactorily. Since a method of designing by test was being sought, a reconciliation of the apparent contradictions between theory and test results had to be explored. To find the answer, attention was turned to the behavior under load of the steel being used in pipe wall and flange. Also, the stress factors in the formulas were further examined to discover whether or not a different concept of design would compose the apparent differences between theory and test results. It was found that theory fits the data when the concept of calculated *stress level* design is displaced by a concept of *limiting-strain* design. Then there was good correlation between theory, the test results and past field experience and practice.

Engineers and designers have been accustomed to thinking in terms of maximum allowable stress. This is fitting and proper as a generalized design principle. There are occasions when the limitations of classical design formulas are exceeded, however—specifically when the proportional limit of the material is exceeded and the load causes bending. This does not necessarily signify that failure will occur. On the contrary, many structures and much equipment now in existence carry, without damage, calculated and actual stresses in excess of the proportional limit of the material. To find an explanation of stress formula results in this instance, an examination of the significance of the stress-strain diagram of a material and its relationship to stress calculations is in order. Such an examination will explain why it is

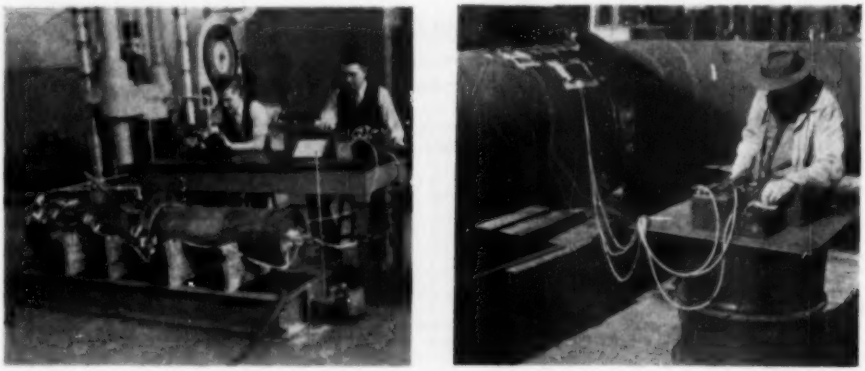

FIG. 2-3. Flanged Joint Test Setup

possible to operate successfully certain classes of structures at calculated stresses beyond the proportional limit of the material and even into the region of yield.

A stress-strain diagram for any given material is a graph showing the strain (or stretch per unit length) which occurs when the material is under a given load. For example, consider a bar of steel being pulled in a testing machine with suitable instrumentation for measuring the load and indicating the dimensional changes. It is found that while the bar is under load it has stretched. The change in length under load per unit of length is called "strain" or "unit strain," which is usually expressed as percentage elongation or, in stress analysis, microinches per inch. A microinch (μin.) is one-millionth (0.000001) of an inch. The values of strain are plotted along the horizontal axis. For purposes of plotting, the load is converted to units of stress in pounds per square inch by dividing the load in pounds by the area of the bar in square inches. The values of stress are plotted along the vertical axis.

Both the engineer and the designer have been inclined to give too much consideration to the *stress* or *vertical* axis of the stress-strain diagram and too little consideration to the *strain* or *horizontal* axis, as will be pointed out.

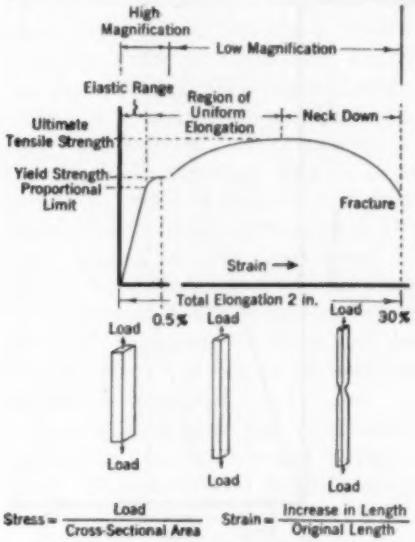

FIG. 4. Stress-Strain Curve (Low-Carbon Steel)

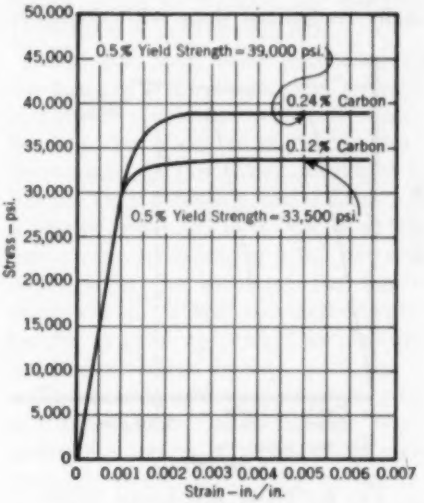

FIG. 5. Stress-Strain Curves (Medium-Carbon Steel)

Figure 4 shows various parts of a pure tension stress-strain curve for low-carbon steel. The change in shape of the test piece during the test is shown by the bars drawn under the curve. As the bar stretches, the cross section decreases in area up to the maximum tensile strength, at which point local reduction of area, or necking-in, takes place.

Many of the materials used in construction have stress-strain diagrams

of the general form shown in Fig. 4. Many other materials used structurally and for machine parts have much higher yield and ultimate strength with reduced ductility. Still other useful engineering materials are quite brittle. In general, the low-ductility materials must be operated at relatively low strains, even though they may have high strength.

The ascending line in the left-hand portion of the graph in Fig. 4 is straight or nearly straight and has an easily recognized slope with respect to

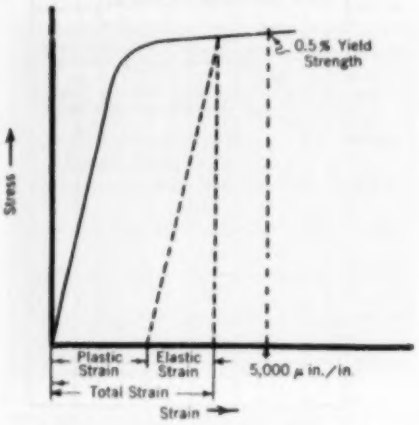

FIG. 6. Plastic and Elastic Strain

the vertical axis. The break in the curve is rather sudden. For this type of curve, the point where the first deviation from a straight line occurs marks the proportional limit of the material. The yield strength is at some higher stress level in such material.

Stresses and strains which fall on the straight portion of the ascending line are said to be in the elastic range. Materials loaded to create stresses or strains within that range return precisely to their original length when the load is removed. It is also true, within this range, that the stress increases in direct proportion to the strain, and equal increments of load add equal increments of strain. The modulus of elasticity, as commonly defined, is the slope of the ascending straight portion of the stress-strain diagram. The modulus of elasticity of steel is about 30,000,000 psi., which means that, for each increment of load that creates a

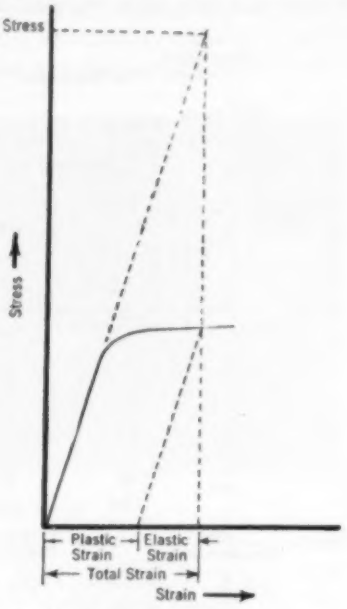

FIG. 7. Actual and Apparent Stress

strain or stretch of 1 μin. per inch of length, a stress of 30 psi. is imposed on the steel cross section (30,000,000 × 0.000001 = 30). Nearly all engineering formulas involving stress calculation presuppose a loading such that working stresses as calculated will be below the proportional limit.

Typical stress-strain curves for two grades of carbon steels used for pipe are shown in Fig. 5.

Immediately above the proportional limit, and between that point and the 0.5 per cent extension-under-load yield strength of the material (Fig. 4), lies a portion of the stress-strain diagram which is becoming of more and more importance to the designer. For lack of a better descriptive, it may be termed the "elastic-plastic" range of the material. Electric resistance strain gages are providing a means of studying that portion of the curve. They and their associated instruments are a kind of microscope which tremendously magnifies the curve and allows minute examination in a manner not possible before their development. Investigation in the elastic-plastic range became a necessity in order to determine and explain the successful functioning of thin steel flanges on thin steel pipe. It should be understood that the range in question is a safe range for certain types of apparatus or structures but not for others. It is safe for steel ring flanges on steel pipe.

Figure 6 shows the stress-strain curve for a material stressed to a given level. The elastic and plastic portions are identified.

Figure 7 shows how a fictitious stress is determined by a formula if the *total* strain is multiplied by the modulus of elasticity. The actual stress is determined by using only the *elastic* strain and the modulus of elasticity, but there is now no way to separate the elastic and plastic strain in a structure. The only alternative is to take the total measured strain as indicated by strain gages and then determine the actual stress on the stress-strain curve as shown in Fig. 8. Attention is thus paid to the *horizontal* axis of the stress-strain diagram.

It is plain that a concept of designing on a basis of *strain* is fairly easy to achieve and it is also evident that analysis becomes more flexible when thinking in terms of *strain* rather than *stress*.

Analysis Based on Strain

Referring to Fig. 4, it is obvious that if the fracture occurred when the elongation was 30 per cent, the corresponding strain over the original 2-in. gage length would be 300,000 μin. per inch ($1{,}000{,}000 \times 0.30 = 300{,}000$).

Steel has long been purchased on the basis of a minimum yield strength in pounds per square inch. By specification this yield strength has been determined as the stress developed at 0.5 per cent extension under load. In a second method, it is taken as the stress corresponding to a 0.2 per cent offset from the slope of the stress-strain curve. These two methods give results in good agreement for the materials considered here.

The first specification method gives a direct means of fixing the yield strength in terms of strain. The yield strength strain conforming to the 0.5 per cent extension under load is 5,000 μin. per inch. It should be noted that this is in pure tension and that a member being stretched less than 5,000 μin. per inch under load is operating below the yield strength even though a calculation using the modulus of elasticity indicates a stress up to 150,000 psi. ($5{,}000 \times 30 = 150{,}000$; *see* Fig. 7).

The principal stresses in a flanged joint, and in the pipe wall adjacent to the joint, are not pure tension stresses, but bending stresses. It should be understood that there are really three distinguishable phases which a member undergoes in bending.

In the first phase, all fibers undergo strain less than the proportional limit in a uniaxial stress field. In this phase, a structure will act in a completely elastic fashion in which the classical laws of stress and strain are applicable.

In the second phase, some of the fibers undergo strains greater than the proportional or elastic limit of the material in a uniaxial stress field, but a more predominant portion of the fibers undergoes strains less than the proportional limit, so that the unit still acts

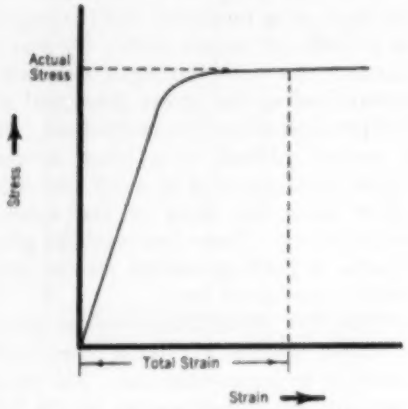

FIG. 8. Determining Actual Stress

in an essentially elastic manner. The classical formulas for stress do not apply, but the strains can be adequately defined in this phase.

In the third phase, the fiber strains are predominantly greater than the elastic limit of the material in a uniaxial stress field. Under these conditions, the unit as a whole no longer acts in an elastic manner. The theory and formulas applicable in this phase are being developed but have not yet reached a stage where general use can be made of them.

The design of the steel ring flange for steel pipe falls in the second phase.

An experimental determination of strain characteristics in bending and tension was made on medium-carbon steel similar to that required by A.W.W.A. specifications 7A.3 and 7A.4 for steel water pipe (3, 4), with results shown in Fig. 9. It is to be noted that the proportional limit strains in bending are 1.52 times those in tension for the same material. Moreover, the specimen in bending showed fully elastic behavior at a strain of 1,750 μin. per inch, which corresponds to a calcu-

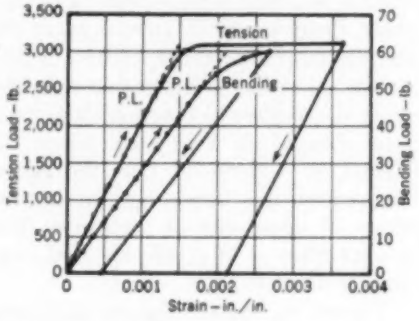

FIG. 9. Experimental Determination of Strain Characteristics

lated stress of 52,500 psi. (1,750 × 30 = 52,500) when the modulus of elasticity is used. The specimens were taken from material having an actual yield of 39,000 psi. Therefore, flanges and pipe made of this steel could be loaded to produce strains up to 1,750 μin. per inch and still possess full elastic behavior.

Calculations were made to determine the strain which would occur in pipe having a wall thickness commonly used in past years when certain standard flanges were attached. These flanges have been used successfully for many years and form a good experience back-

ground against which to make calculations. The sizes ranged from 4 through 96 in. Table 2 shows the results.

It is to be noted that, in practice, the limiting strain has always been below

TABLE 2

Maximum Strain in Pipe Wall Developed in Practice

Standard Flange	Operating Pressure *psi.*	Max. Strain *μin./in.*
A	75	1,550–3,900
	150	2,200–4,650
B	150	1,100–3,850

the commonly recognized yield strength strain of 5,000 μin. per inch but does approach it quite closely in at least one instance. All of these flanges are sufficiently satisfactory, however, to warrant their continued use by designers.

The joint A.W.W.A.-A.S.M.E. flange committee's subcommittee on design is now engaged in evolving standards for 75-lb. and 150-lb. steel ring flanges for cold-water service, using the foregoing information as basic data. This work should be completed soon.

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Discussion

Frank S. G. Williams

Taylor Forge & Pipe Works, New York.

The author is to be complimented upon his presentation which briefly outlines a test program and recommendations made to the joint A.W.W.A.-A.S.M.E. flange committee and which submits the concept of limiting strain for application to the design of flanged joints in water works service.

In water works usage, there are many favorable factors which permit a narrowing of the problem that is not possible in the general field of piping and pressure vessel work. These factors may be enumerated as follows:

1. Consideration can be limited to carbon steel materials of high ductility in which the yield strength is usually on the order of 50 per cent of the ultimate tensile strength.

2. It is practical to limit the problem to the use of soft gaskets, usually of the cloth-inserted type.

3. Water works usage is essentially nonshock service.

4. The thickness of steel water pipe is almost always small in relation to the diameter, which permits a more liberal evaluation of localized stresses or strains than is safe in fields of construction where the ratio of thickness to diameter is much greater.

5. Vibration and, therefore, fatigue failure are not a criterion of design.

6. Service temperatures can be limited to a maximum of 100°F.

7. Stress corrosion is not an important factor.

8. Flanged joints used in water works service are not normally disassembled at frequent intervals.

9. Design can be limited to flanged joints employing flat facing, and gaskets are seldom more than $\frac{1}{16}$ in. thick. Under these conditions, abuse of the flanged joint by an overtightening of the bolts causes the flanges to touch along the outside periphery, thereby bringing an immediate limit to the stresses or strains that can be imposed.

These favorable operating conditions greatly simplify the problems which must be considered, but it should be remembered that such conditions prevail only in a relatively small segment of the broad field of flange design. These limitations are enumerated here as a caution that the factors employed in the author's approach cannot be safely carried over into other fields of usage. Fortunately, existing flange design rules of the A.S.M.E. code do take cognizance of the broader range of variables encountered in the general field of flange application services.

The investigations conducted by Barnard and his associates at Armco and by the Taylor Forge organization developed stress patterns that are in substantial agreement. They also indicate good agreement between the actual stresses measured and those calculated by the formulas developed by Taylor and Waters in 1927 (1), based on an exhaustive set of tests at that time, and modified by Waters and others in 1937 (2) to provide for the tapered hubs necessary in the butt weld type of flange.

The A.S.M.E. Boiler Code Committee, in establishing its rules for bolted flange connections in 1938, recognized what the author has described as the second phase, namely, the condition in which some of the fibers undergo strains greater than the proportional or elastic limit of the material without the structure as a whole going beyond the field of elastic behavior. The bending stress in the hub of the flange, or pipe wall, was permitted to exceed the normal maximum allowable hoop stress by 50 per cent, provided the average of the other stresses was within the allowable limit. This concept recognized the permissibility of local yield-

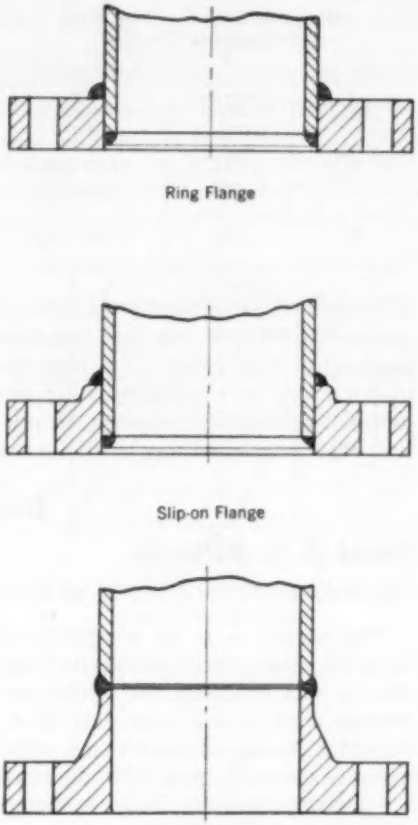

FIG. 10. Types of Flanges

ing as long as there was sufficient reserve capacity in the other sections to carry the increased loads that would be placed upon them when this localized yielding occurred. The point which the author makes is that the extent of the local yielding may be permitted to exceed the elastic properties of the material locally while still keeping the assembly in phase two. The proposed evaluation in terms of strain, in place of the more conventional concept of the stresses resulting from strain, is a perfectly proper approach. The author has reported that these concepts, when fitted to the A.S.M.E. formulas, produce consistent results.

Although the author has confined his investigation to a flange of rectangular cross section attached to the pipe by fillet welds, it should be recognized that the rectangular ring cross section is not the most economical usage of material. For this reason, the Taylor Forge investigations were carried further, using both ring cross section and conventional hub flanges of a slip-on type. In the field of low-pressure piping and relatively thin wall thicknesses, the slip-on construction is convenient, but, when pipe walls approach ½ in. in thickness, the substantial reinforcement provided by the tapered hub in a welding neck flange, combined with the mechanical and design advantages of the butt joint as compared with the double fillet weld, clearly indicates the desirability of producing standards for all three basic forms of flanges—the ring and hub type of slip-on flange, and the welding neck type (*see* Fig. 10).

The hub flange is admittedly stronger than a flat ring flange, provides a more advantageous transition section between ring and pipe and is usually preferred by the more discriminating designers.

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Author's Closure

The author thanks Frank S. G. Williams for his compliment and for his written discussion.

The author agrees that the concept of design by limiting strain cannot be safely carried over into other fields of usage without further study and evaluation. He believes that such study is in order, however, because the concept of limiting strain, once grasped, provides the designer with some fundamental and governing facts which shed light on the behavior of material in many instances where the stress concept offers no reasonable explanation. The study is especially applicable when the overall design of a unit is made subservient to an analysis of concentrated localized stresses (held to low classical design limits) using formulas beyond the range in which they apply, with the end result that the designed unit becomes uneconomical.

Stress cannot be measured directly by any methods at the designer's disposal. It is a calculated result obtained by using factors of load, area and length change, which can be measured by present instruments. It may be very wise to begin thinking in terms

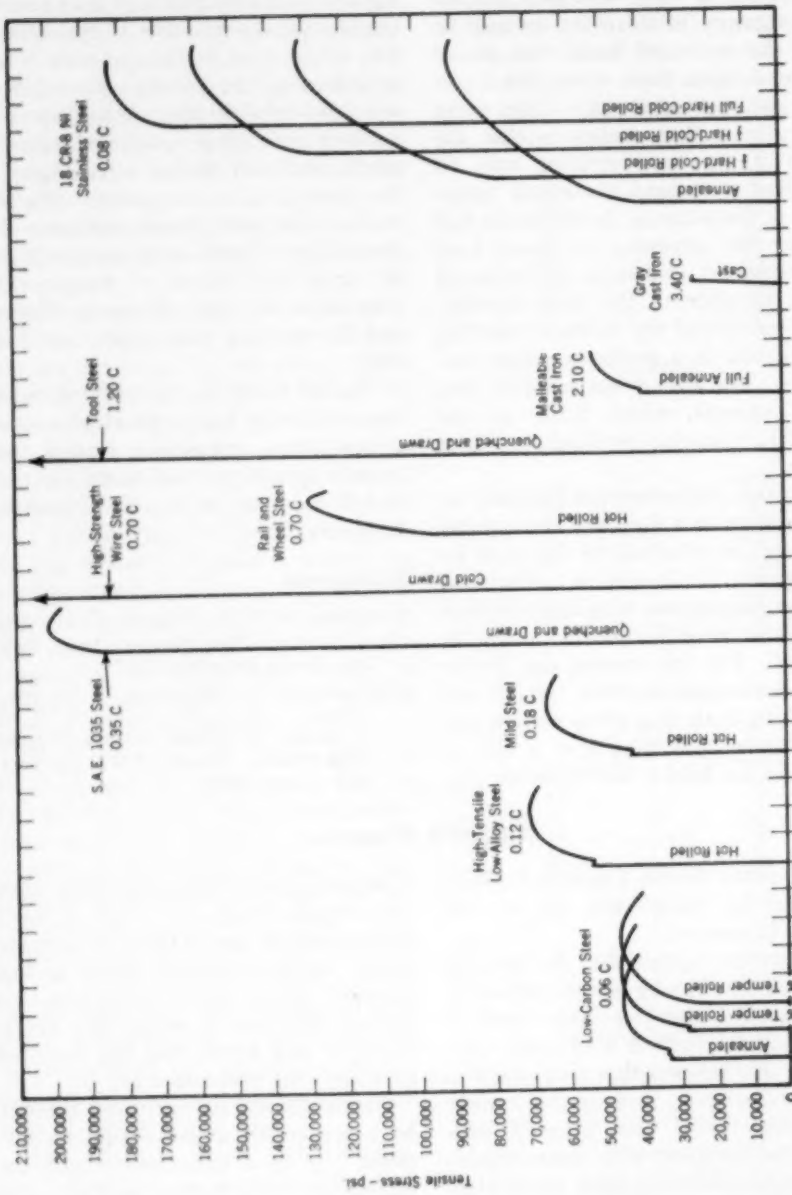

Fig. 11. Tensile Stress-Strain Curves of Typical Steels and Irons

of the factors in material behavior which can be measured. A stress-strain, or load-strain, diagram of a particular material pulled in tension gives an actual picture of its behavior under load. And this picture is complete from no load condition to failure load condition. For every value of measured strain, there is a corresponding value of stress on the stress-strain curve. Therefore, to change from "stress thinking" to "strain thinking" is not difficult. It is a shift from thinking in terms of value on the vertical axis to thinking in terms of value on the horizontal axis of the curve. As pointed out in the paper, the strain measurements are not subject to the kind of error in the region of the proportional limit that a calculated or apparent stress value is subject to.

The theory of limiting strain is not confined in application to ductile materials only. Stress-strain diagrams for several steels and irons are shown in Fig. 11. The scale to which these diagrams are drawn does not disclose clearly the slope of the rising line, but the elongation scale can be greatly magnified for study when SR-4 strain gages are used. This is plainly shown by comparing Fig. 9 in the paper with the line for hot-rolled mild steel in Fig. 11 (fifth from left).

The limiting strain for brittle materials can be determined in a fashion similar to that used for ductile materials. The limiting strain will vary greatly, but, for every allowable stress for a given material used in present-day design, there will be found a corresponding strain, and it will be measurably related to the load.

As an example, a design stress of 9,000 psi. in mild steel corresponds to a strain of 300 μin. per inch, and a design stress of 15,000 psi. to 500 μin. per inch.

It is interesting to apply the limiting-strain theory to the behavior of cracks as so-called stress raisers and to notch sensitivity. Annealed copper is not considered a notch-sensitive material in the true sense. A piece of small, soft copper wire may be practically tied in knots and untied without breaking. But if that same copper wire is chromium plated, it will break brittle with little bending. If the chromium plating is removed, the copper wire can be tied in knots again. Why did the ductile copper wire break?

Suppose the elongation of the copper at the breaking point is 50 per cent and that of the chromium plating 1 per cent. The outer fibers of the unplated wire can be elongated without breaking until the stretch per unit of length is 50 per cent. In the process of knot-tying, no unit of outer fiber length has been stretched as much as 50 per cent and the wire remains unbroken. The total stretch has been more or less distributed over some distance.

When the plated wire is bent, the outer fibers of the unit are chromium and do not stretch very far before cracking. After the plating has cracked, the copper takes the load but now it cannot distribute the stretch. The crack extends from the plating right on into the copper because the stretch is concentrated in the infinitesimal distance of crack width. Even though the copper stretches 50 per cent in this highly localized area, the overall stretch of the wire is practically zero. The limiting strain has been exceeded in the bottom of the crack and the still ductile copper appears to break brittle.

Notch effect in hard material can be analyzed in a similar manner. Replac-

ing a notch by a rounded fillet adds to the distance over which a fixed increase of length is spread. The effective surface length of the fillet related to the limiting strain of the material in question is the criterion which measures the ability to survive or fail when a stretching load is applied.

The behavior of surface-hardened material, and the effect of flame cutting edges and other operations which reduce surface ductility may well be examined as in the copper wire example.

The satisfactory performance of flexible steel pipe rather severely deformed by exterior earth loads is not explained by the classical stress formulas. Since failure does not occur, it seems evident that the strain concept may well be applied in an effort to find the explanation.

Failure at the root of threads is another instance of limiting strain in action.

The ability of bolts to hold securely and safely, especially under vibration conditions, when they are drawn into the region of yield, is easily explained by the strain concept but not by the stress concept. Incidentally, overtightening of flange bolts above the design load is common practice in fields of use other than water service. Thinking about flanged joints and bolts in terms of limiting strain makes much clearer the reason for their satisfactory service.

In the overall dollars-and-cents economy of structures and devices there are the factors of using the least amount of material to do the job properly, the least cost of forming or fabricating those materials and the lowest assembly cost in plant and field. The designer's job is to relate loads to resistance of material. The newer instruments for stress analysis permit a direct approach primarily to the problem of designing parts by testing to assure proper performance. The related theory can be developed at the same time. The procedure of designing by test makes it possible to determine the limit of satisfactory performance. Experience has shown that this procedure results in economies both for the manufacturer and the consumer. Whether one or another satisfactory design is the more acceptable will be decided finally on a basis of dollar cost. Steel ring flanges, hub flanges and welding neck flanges are no exceptions.

Prospecting for Ground Water

Panel Discussion

A panel discussion presented on May 25, 1950, at the Annual Conference, Philadelphia, by R. M. Leggette, Cons. Ground Water Geologist, New York; Carl A. Bays, Pres., Carl A. Bays & Assoc., Inc., Urbana, Ill.; T. W. Thorpe, Pres. & Gen. Mgr., Thorpe Well Co., Des Moines, Iowa; John G. Ferris, Dist. Engr., Ground Water Branch, U.S. Geological Survey, Lansing, Mich.; and John J. Baffa, Cons. Engr., New York.

Geologic Methods—*R. M. Leggette*

IN any panel discussion of prospecting for ground water, it is entirely proper that geologic methods be given first consideration, for it can truly be said that all ground water problems are basically geologic. Moreover, a consideration of the geology of an area should generally be the first step when prospecting for ground water. Water-bearing formations are geologic units and the composition and structure of such units often control in great measure the quantity and quality of water available.

The geologic approach to most ground water problems consists merely of applying the known geology in all of its phases to the problem of water supply. In some areas, the geologic information available in published reports and maps may be adequate for a tentative appraisal of the ground water conditions. In other areas, additional geologic field work may be required to evaluate the ground water prospects properly. Often test drilling is required to furnish more detailed geologic information. A consideration of the geologic history, or sequence of depositional and erosional events, may have an important bearing on the ground water conditions. A knowledge of the mode of deposition of a geologic formation may indicate whether uniform water-bearing properties are to be expected or whether the formation is likely to be irregular over short distances.

Water-bearing Properties

It should be recognized that many types of geologic units have rather characteristic water-bearing properties. Some types of formations may be expected to yield up to a few thousand gallons per minute or more from one properly constructed well. Other types of geologic units cannot be expected to yield more than a few gallons per minute or less from one well. Thus, a formation may be completely satisfactory for a domestic water supply but thoroughly inadequate for an industrial or public supply. Sand and gravel formations can generally be expected to yield large quantities of water. In contrast, granite, gneiss and schist usually furnish only small amounts of water. Other types of formations are quite irregular in their water-bearing properties. Sandstones or shales, for example, may be rather good water-

bearing formations in some areas but relatively poor in others. Limestones are commonly very irregular as water-bearing formations, two nearby wells often showing great differences in yield. In some areas, however, limestones may be persistently either good or poor water producers. A study of the geology of an area may indicate that a sandstone or shale is well fractured or that a limestone contains many solution channels, thus indicating better water-bearing conditions than if few such openings were present.

In some areas, a geologic unit known to be a good water-bearing formation may not be the uppermost stratum. It then becomes important to have a basis for determining the depth at which the water-bearing formation will be encountered. The nature and thickness of the overlying formations and the dip of the water-bearing formation can often be determined by geologic studies, and these will provide a basis for estimating how deep the contemplated drilling must be.

Artesian conditions are the result of particular geologic features, chiefly the structure of the beds and the presence of relatively impervious material overlying a water-bearing formation. A knowledge of the geology of an area enables one to predict the presence or absence of artesian conditions and the likelihood of obtaining flowing wells.

Mineral Content

The content of dissolved mineral matter in ground water is largely determined by the geology of the area. Precipitation, the source of all ground water, contains little or no mineral matter. Ground waters commonly are somewhat, if not highly, mineralized. This increase in mineralization is the result of the water's having been in contact with rock material. Areas underlain by the more soluble rocks yield more highly mineralized water than areas of less soluble rocks. Waters from limestone areas are commonly hard. Waters from igneous and related types of rocks are generally low in mineral content. If the formations in an area are known to contain beds of salt or gypsum, the waters may be expected to be high in chloride or sulfate content. Water from coal-bearing rocks may be acid and often contains excessive amounts of iron. In some areas, waters from glacial gravels may be rather hard.

Importance of Geologic Studies

During the preliminary stages of considering an area for a proposed ground water development, careful study of the geology is usually desirable. Sometimes the available published geologic information, without further field investigation, may be adequate to establish whether or not the proposed project is feasible. Many industries in need of large supplies of water have wasted considerable money drilling in areas whose geology was known to be unfavorable for large-capacity wells. Even a glance at the geologic map would have shown that wells yielding only a few gallons per minute could be expected. At other times large expenditures have been made for surface water developments in areas where the geologic conditions were entirely favorable for adequate and much less costly ground water developments.

The application of geologic methods in the search for ground water supplies is a sound and economical approach to the problems of determining the available water resources of an area.

Geophysical Methods—*Carl A. Bays*

Although the primary purpose of this panel discussion is to treat the problems of exploration for ground water, it should be noted that the judicious use of geophysical methods, measurements and instruments can find application not only in this field but also in the maintenance and operation of water works with underground supplies. But only if the information provided by geophysical methods can be intelligently and economically used are the applications of those methods justified.

Most geophysical methods furnish information which is a measure of physical contrasts that may exist in the earth materials where ground water occurs or in drillholes. The data are indirect measures of the geologic or hydrologic conditions which control ground water production. Geophysical methods can never supplant geologic, hydrologic or test-drilling investigations and serve only to augment them by giving fuller or more detailed information. Sometimes geophysics proves a means of obtaining information more economically than by using other methods of ground water exploration.

In order to survey the overall field of geophysics in its possible applications to ground water exploration, case histories of successful use of these methods will have to be omitted. Any attempt to make an unbiased evaluation of geophysical methods should frankly state that these tools cannot be used independently of geologic and hydrologic know-how and cannot be expected to provide any cure-all for all the problems of ground water exploration, development and maintenance. It is therefore necessary to point out how geophysical methods can be integrated with the other methods of prospecting and development and how the data from all lines of prospecting can be tied together into an economically satisfactory exploration program.

Principles of Application

Since geophysical methods measure physical contrasts, it is futile to consider the application of any geophysical technique to a problem involving insufficient or immeasurable contrasts. Before such applications are attempted, an analysis should be made to see whether usable contrasts exist. Sometimes a logical analysis is enough, as in the mapping of sea water invasion, where it can be readily reasoned that a contrast is present. Often the preliminary analysis can be made with simple measurements in the field or laboratory at small cost.

Today in many branches of geophysics the state of knowledge is such that experience and analogy may be used to predict in a preliminary fashion the existence and extent of physical contrasts. It is necessary, therefore, to know as much about the geology and hydrology as possible to determine whether physical contrasts of measurable significance may be present in an area and indicative of conditions in which ground water occurs. It is not always essential, however, to complete geologic or hydrologic investigations prior to geophysical exploration, because, in most areas, enough is known or can be found out from the literature and from people on the ground to aid the preliminary analysis required.

In order for geophysical exploration to be economical in its application to ground water prospecting today, it is necessary for it to be relatively simple.

Uncomplicated but tailor-made instrumentation is widely adaptable if contrasts are present for which such methods are applicable. Generally, the field of ground water has yet to justify the highly complex and expensive procedures that have been developed and have found wide application in petroleum exploration. Therefore, it is usually necessary, in the water supply field, to look to instruments and methods of simple and inexpensive operation and construction which give quick and effective answers. Of course, the willow or witch-hazel wand almost ideally fulfills these requisites, but the physical contrasts it may measure are as yet unknown. If water becomes as scarce as some alarmists feel it might, more costly and complex geophysical exploration techniques are available and can be applied to the problems of that time, but, until such necessity arises, economical geophysical exploration will be based upon the simple and rapid measurement of physical contrasts which are indicative of the geology and hydrology of ground water occurrence.

In considering possible methods of geophysical prospecting for any particular area or problem, a number of alternative methods are often available. These are based upon measurements of various properties of matter or differentiation between the properties of two types of earth materials, one capable of yielding ground water. Table 1, though not complete, gives most of the methods which can possibly be applied to ground water exploration and the properties with which they deal.

Geologic and hydrologic variations from place to place beneath the earth's surface are reflected in the variations of one or more physical properties. Variations in the physical conditions mentioned in Table 1 all present contrasts which have been used in ground water prospecting, but only a few of the methods have found wide application. Any situation requiring prospecting can be analyzed in relation to this list to determine which method or property, in the light of available information, deserves consideration for effective use.

TABLE 1

Geophysical Methods Applicable to Ground Water Prospecting

Method	Property of Matter
1. Radioactivity	spontaneous disintegration
2. Gravity	density
3. Seismic	transmission of elastic or sonic waves
4. Magnetic	permanent or induced magnetic fields
5. Electrical potential	voltage differences
6. Electrical resistivity	conductivity differences; transmission of electrical currents
7. Thermal	temperature or heat conductivity differences
8. Electromagnetic	transmission of electromagnetic waves; behavior in electromagnetic fields

Radioactivity

Differences in radioactivity rarely imply absolutely the occurrence or non-occurrence of ground water. Because frequently there are differences in radioactivity between geological units which are water-bearing and those which are not, however, it is conceivable that the property of radioactivity could be used as a surface-mapping device for delimiting belts of more radioactive rock from those less radioactive, thereby indicating the areas to prospect for ground water. The shales and associated clayey rocks generally have somewhat higher radioactivity than do limestones or dolomites. Sandstones are intermediate. It is possible,

with some radioactivity measuring devices of a rather simple nature, to map the distribution of such units. But burial at very shallow depths under soils, glacial drift and the like so masks the effects of such differences in radioactivity as to preclude any widespread use of this method, and it can be applied only under a few very specialized conditions.

Radioactivity as a property of rocks, however, has been and will become increasingly important in the study of drillholes. The widespread use of radioactivity logging in drillholes in the oil industry has demonstrated the importance of this method, especially in logging cased-off portions of drillholes. In a few areas, it has been possible to make use of these logs in ground water exploration, in tracing and locating aquifers to evaluate their extent and the mineral content of waters. Radioactivity logging of existing water wells has been applied only once or twice to locate and prospect for water supplies.

Particularly in regions where oil exploration has taken place, there will be wider application and use of these methods in the future. Those involved in ground water exploration should be informed of the existence, utility and application of such methods.

Another phase of radioactivity which can be of importance in ground water problems is the use of radioactive tracers. In many pollution and similar problems, such as recharge, use has been made of dyes, salts and other means of tracing fluid movements. Most such work has ignored the role of diffusion, which can be an important consideration (1).

Radioactive materials, because of simplicity of testing and economy, can find much wider use in problems of ground water exploration and development.

Gravity Methods

Gravity methods measure the differences in density from place to place on the earth's surface and these reflect geological structure. In ground water exploration, the difference between water-bearing and nonwater-bearing terrane is seldom reflected in variations in the specific gravity of the rocks involved or in measurable differences in the force or acceleration of gravity at the surface. Conceivably, such variations can exist under fairly specialized geologic conditions, as, for example, the location of thick alluvial deposits at the foot of mountainous areas. In much of the actual exploration for ground water, however, insufficient contrasts are present for effective use of this method, or others are more applicable. Gravity exploration requires topographic and latitudinal correction of field data and generally entails too much expense to make its use justified in most current ground water exploration. Only in very specialized instances would gravimetric methods find useful application for ground water prospecting.

Numerous applications of gravity mapping have been made where strictly geological problems, related to water supply projects, but not necessarily to exploration, are concerned—the ground structure at a proposed dam site, for example.

Seismic Methods

Most materials have the property of transmitting elastic (or sound) waves. Generally, these waves are transmitted at much lower velocities in soft mate-

rials and at much higher velocities in firm or indurated materials. Boundaries of masses of rocks of different transmission properties will reflect and refract such waves. The seismic methods, which measure the behavior of elastic impulses reflected or refracted by such boundaries, are, of course, most widely adapted to oil field exploration. In this type of work, explosives are used to generate the elastic wave and geophones of high sensitivity receive the signals at the observation points. The signals are amplified and recorded by portable seismograph equipment. Only a small part of the lower-frequency portion of the sound spectrum, generally 20 to 100 cycles per second, is used in such work because of the greater attenuation of higher-frequency signals and the usual desire to make measurements to considerable depths and across great distances.

Rocks and soils near the surface transmit the waves at much lower velocities than the more deeply buried materials. Water contained in the pores of earth materials partly controls the velocities of transmission.

In prospecting for ground water, the seismograph, commonly in simple form, has been used directly for the location of water-bearing materials, for geologic mapping of subsurface conditions and in specialized problems, such as locating or mapping buried glacial valleys where water-bearing materials occur. Many of the applications of seismic methods have been very successful. Their wider use for ground water exploration is restricted for economic and technical reasons. Most of the available seismic equipment is designed for deep operation and, therefore, is highly expensive and complicated for field operation. It uses the low-frequency range and tends to fail to get usable information in the near-surface, low-velocity zone which is usually of interest in ground water exploration. The operation of this equipment and the interpretation of the records requires several persons, most of whom have to be technically trained and experienced. Even the simpler forms of seismograph which can be applied require some technical skills in their operation and in translation of the records into useful information.

In time it is to be expected that water supply prospecting will provide an economic impetus for the development of the special types of seismic tools which are practical for these exploration problems. Much experimental work has been done already and a number of different instruments, some using higher frequencies and others using simple methods of operation and interpretation, have been developed. As experience accumulates both in the understanding of the geological conditions controlling the occurrence and production of ground water and in the employment of seismic instrumentation, it seems likely that there will be much use of seismic methods in ground water prospecting because they are very widely applicable to many types of exploration problems.

Magnetic Methods

Magnetic methods measure permanent or induced magnetic fields of the earth and naturally or inductively magnetized earth materials. They thus deal with geologic contrasts which are only rarely related in any way to the occurrence of ground water. It is conceivable that, under very special geologic conditions, the magnetometer

or even the dip needle could find some application in ground water prospecting, primarily in geologic mapping. In most American ground water supplies, however, little use could be made of magnetic methods in obtaining information to guide exploration or development.

Electrical Potential

Ground waters with different electrochemical properties and geologic units of different lithologies are characterized by potential (or voltage) differences. The movement of waters through pores, fractures or crevices in earth materials also causes differences in potential. Sometimes these potential differences are reflected or are mappable at the surface, using some form of simple potentiometer. Under many typical geologic conditions, however, soils and cover which are good conductors mask the effects of such potential differences occurring at any appreciable depth. It is also often true that, where potential differences exist, resistivity differences are also present, and, since the methods of measuring resistivity (described below) are frequently more rapid than the potential methods, the former are preferred.

In water supply exploration, one of the most important uses of the potential contrast is in drillholes. Where exploration test holes are drilled, potential logs are used to determine the location of porous and permeable zones and the relative importance of different zones. They can also be used for differentiating salt and fresh water zones and for estimating with reasonable accuracy the saline content of ground waters. Work of this type has recently been described by Bryan (2) and has been done by several others (3–5). Drillhole logging methods have also been discussed in several publications by the author (6–8).

Equipment for drillhole logging ranges from the exceedingly simple, portable apparatus shown in Fig. 1 (where potential differences between the ground surface and a traveling electrode in the drillhole are read directly from a potentiometer and recorded manually) to truck-mounted instrumentation of the recording type.

Electrical Resistivity

Porous rocks or unconsolidated materials containing fresh water generally have much higher electrical resistivity than the adjacent or surrounding materials, which may contain mineralized water, clay or silt, or be nonwater-bearing. This contrast in resistivity, in many areas, is measurable from the surface. Most applications of the resistivity method in the United States have been in the location of water-bearing sands and gravels in the glacial drift or alluvium. The method has been used throughout the world, however, in the exploration of bedrock as well as unconsolidated aquifers. The most extensive work of this type in America has been done in Illinois (9). Investigations in Africa and the Mediterranean area have recently been described by Paver (10).

The equipment used is highly portable and consists simply of a means of applying a current to the ground and measuring the potential drop or resistivity in the applied field. In practice, an a-c. low-frequency system is used in preference to direct current to avoid the problems of polarization and man-made influences. The electrodes at the surface are commonly spaced equally in the Wenner configuration, so that

the electrode spacing is approximately related to the maximum depth of the materials affecting the reading. A resistivity investigation consists of taking a series of readings at one place with successively wider or narrower electrode separations to cover more than the zone of maximum interest.

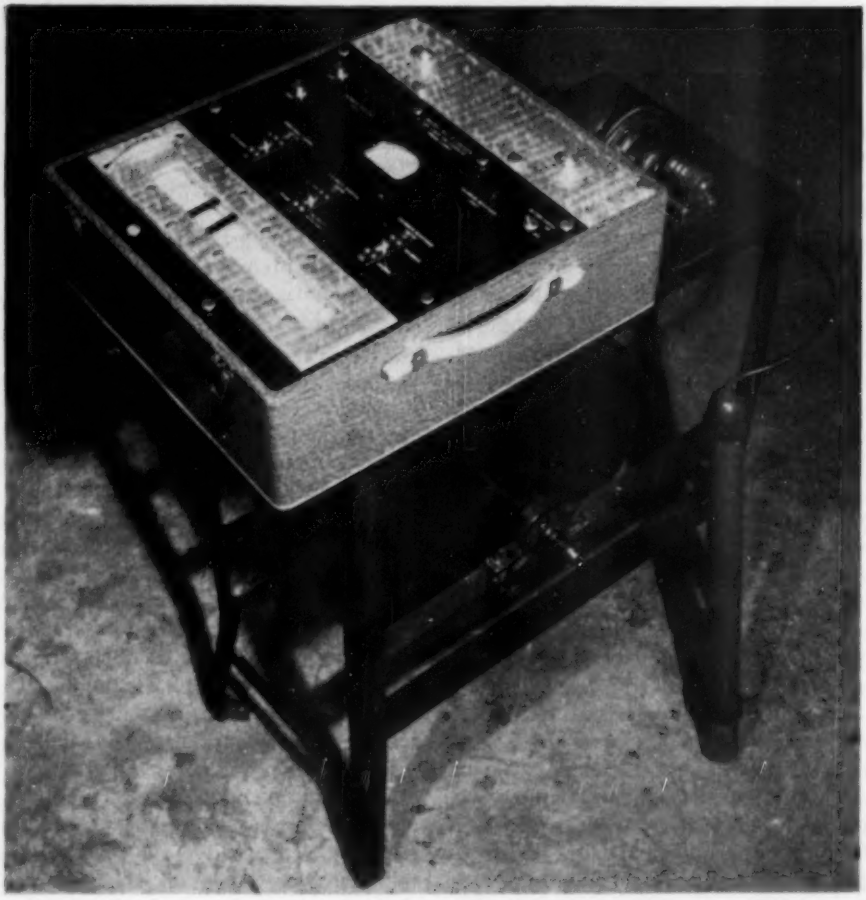

FIG. 1. Portable Direct-Reading Logging Equipment

A portable surface resistivity instrument, with battery case, field line reel and electrode stake of modern design, is shown in Fig. 2. This equipment is the lightest possible type for making ground resistivity measurements to considerable depths with low-frequency alternating current. The instrument gives the reading in resistivity directly for any electrode separation. Meters indicate current applied to the ground and resistivity values.

In alluvium and glacial drift, the contrasts below 300–400 ft. are generally not readily detectable from the surface with resistivity methods, which

are therefore best applied at shallower depths. Also, because of the relatively coarse nature of the method, thin or small water-bearing deposits, quite often suitable for a minor domestic, farm or industrial supply, are not readily located by resistivity.

Resistivity measurement is a prospecting tool which serves best to guide test drilling and reduce the number of test holes required. The method operates, first, to condemn large areas in which prospecting may not be justified. Second, the data can be interpreted to locate areas which merit test drilling. Third, within these areas, after a minimum number of test holes have been drilled to obtain data on texture, hydrology and other items of proper well design, the resistivity information can be used to delimit the size or extent of the deposit involved and thereby eliminate the "proving" test holes so often required.

Exceptional success has been attained with the resistivity method in ground water prospecting on the types of problems for which it is applicable. By themselves, however, the data found are often not directly interpretable into the answers required and must be augmented by both geologic and hydrologic data from the area under investigation. Available water level records, well logs and similar information are necessary for the proper interpretation of the resistivity data in most successful applications.

Resistivity measurements are also extensively used in logging techniques (*2*, 6–8). Advantage is taken of the differences in resistivity of salt water–bearing and fresh water–bearing formations. Also, the location of permeable and porous zones is indicated by the resistivity logs of wells—data which are of importance in the placement of screens, in shooting or acidizing, and in other completion and development work.

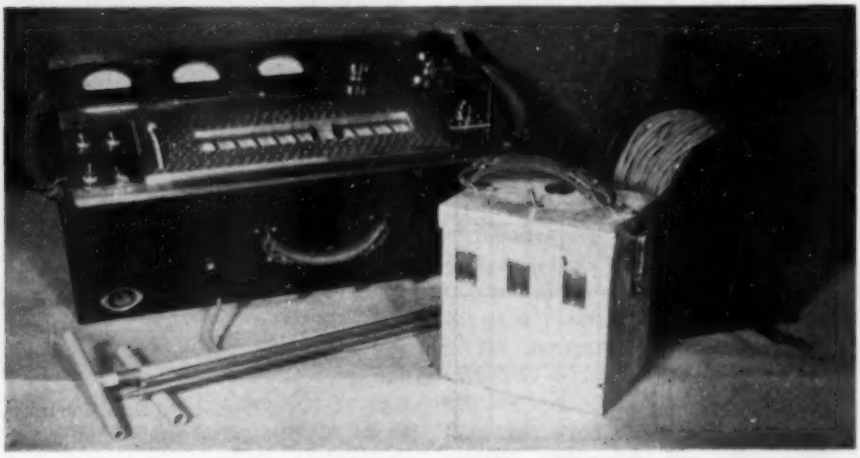

FIG. 2. Portable Surface Resistivity Instrument

Figure 3 is a graph of the potential and resistivity log of a rotary test hole. The data were obtained with a portable logger. Permeable sand is shown

on the potential log to lie between 150 and 175 ft. The resistivity log, however, shows the fresh water–salt water contact to lie at 120 ft. Prior to the adoption of logging in this area, it was the usual exploration practice to set screens at various places in the test holes to obtain samples for chemical analysis in order to locate this contact.

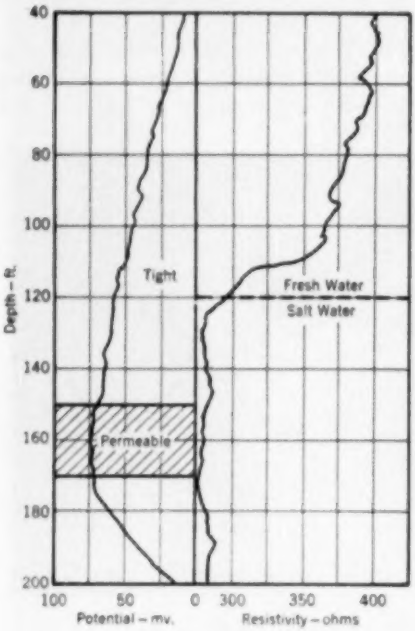

FIG. 3. Potential and Resistivity Log

In the repair and rehabilitation of water wells and the checking of specifications on new wells, resistivity logs are used because of the contrast between casing or screen materials and the natural formations. Electrical devices which are based on resistivity are also employed in other phases of geophysical logging—such as measurements of hole diameter, temperature, fluid resistivity and sometimes fluid flow. Essentially the same resistivity measuring instruments are used for all these types of drill hole records, with different devices being run into the well.

Geothermal Methods

The thermometer is not widely used as an instrument of investigation in ground water prospecting. As a prospecting tool, it is not important in its possible applications because there are no simple, relatively inexpensive sur-

FIG. 4. Vehicle-mounted Field Intensity Recorder

face methods for getting underground temperature data indicative of the geologic variations. The temperature of ground water produced is, however, of increasing importance in the field of water utilization. In this connection, the thermometer is a necessary adjunct of geophysical exploration or of water development and operation.

As each well is completed, its discharge temperature should be measured and recorded. Changes in temperature from time to time are often indicative of changes in the condition of the

well. Abnormally cold temperatures may indicate the presence of gas and thereby suggest safety precautions that should be taken. Or, if the well is of considerable depth, cold water may be indicative of shallow pollution or contamination. Likewise, abnormally warm water may imply leaks into the aquifer or deep-seated origin of the water. The thermometer provides a good indicator of a return to normal after acid or other chemical treatment or repair work.

The uses that may be found for temperature measurements will vary from territory to territory, but they are simple applications which can usually be undertaken by any operator or driller. Temperature measurements, of course, are widely used in drillhole logging to indicate the position of cement behind casing in new wells or to locate the source of gas, while, in multiple-zone geophysical logging, they serve as an index of circulation which may be taking place in the well bore.

Electromagnetic Methods

The application of electromagnetic methods to ground water exploration problems may be considered to be in its infancy. The methods themselves consist of several types of measurements that can be made on induced fields or transmitted electromagnetic waves. Such fields or the intensities of the waves vary with the subsurface geologic features and therefore may be used to augment other geologic mapping or prospecting techniques. Electromagnetic methods have been applied particularly in fault location and related geological problems which can be of importance in ground water investigations (11). Full knowledge of the numerous possible methods of electromagnetic measurement and instrumentation will require much more work on the part of geophysicists. Preliminary development to date has resulted in simple, highly mobile instrumentation which can be employed in some problems of geologic mapping in connection with ground water prospecting (Fig. 4). Time and economic impetus can be expected to produce a better technical understanding of the applications of electromagnetic methods to various types of ground water exploration.

Technical Aspects

Without question, the development and evaluation of geophysical methods have required rather specialized training and experience. Today, however, many of the methods have been simplified, as in well logging and resistivity prospecting, so that any person with an elementary knowledge of the subject and basic common sense can do the routine work and, if familiar with the area under investigation, make most of the necessary interpretations. Nevertheless, some methods do continue to require specialists for successful operation, but even these often prove economical because of the relatively low cost of obtaining the geophysical data.

Probably one of the greatest hazards to the proper application of geophysics is the pseudo-geophysicist who is interested in selling a particular method regardless of the physical contrasts present. A number of partly trained or untrained persons have attempted to locate ground water with radar, although the short waves used in radar penetrate earth materials to such slight depths—usually a fraction of an inch—that they have no conceivable utility in ground water prospecting. Even

highly trained engineers, as well as public officials responsible for ground water exploration programs, have readily fallen prey to this type of "geophysicist." For that reason, this discussion has emphasized the basic physical contrast as a means for analyzing the applicability of any geophysical method.

The ethical use of geophysics demands a sound basis for application and requires primary geologic and hydrologic data before recommendations and conclusions can be formulated. The pseudoscientific methods are frequently founded on superstition or unsound physical principles which are readily evident upon analysis. Most usable geophysical data are readily reproducible and can be integrated with other known geologic and hydrologic facts. They can be analyzed or explained in language that is intelligible to any one. If, however, those responsible for employment of geophysics in ground water prospecting do not understand or investigate the methods used by geophysicists, they will continue to risk the intentional or unintentional misapplication of such methods.

Summary

Numerous types of geophysical methods can be widely and economically used in ground water exploration and development. Some can find application only under highly specialized geologic or hydrologic conditions. The various geophysical methods do not offer any universally applicable means for the discovery of ground water nor can they supplant the necessary geologic, hydrologic and test drilling investigations. They can best be employed to reduce the costs of exploration and augment the other methods of prospecting that are usually required. Specialized knowledge may be necessary in applying them, as in the other methods of exploration, but most usable geophysical methods are simple in procedure and instrumentation and can be understood by any who have need of them.

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Test Drilling—*T. W. Thorpe*

Testing for ground water is usually taken to mean exploring sand and gravel deposits, but this is only part of the problem. Modern testing requires a much more extensive approach, as a great deal of information about the lower aquifers is needed to develop the best and most economical supply. For example, a shallow supply is often overpumped and additional wells in the same formation would merely postpone trouble. It must then be decided whether to utilize another drainage area several miles away or drill down into the rock for a deeper supply.

Unconsolidated Formations

In testing an unconsolidated formation, either bailing, with cable tools, or wash boring, generally by the rotary-drill method, is used. When proper equipment is employed, the former is usually conceded to be the more accurate way to get representative samples. The rotary method leaves a great deal to the drill operator, and, at best, the samples are rather mixed up as they are pumped out.

In the bailing method, a sufficient amount of casing is necessary so that it is free to follow the bailing and shear its way through the sand and gravel. It is also very important to use the proper size and type of bailing equipment. If the bailer is too large for the casing or is removed too fast, a plunger action is created in the casing, and the sand may follow the bailer up the hole and not give a representative sample. It helps considerably to keep the casing filled with water above the static head. A suction or plunger bailer should be used. The heavy barrel sinks into the sand as the plunger is raised, and the sand enters at the bottom, going up under the plunger. A valve in the bottom of the barrel closes when the latter is raised.

Water samples can be taken by bailing slowly from the top in order not to cause the sand to shoot. It is necessary to remove the water put into the hole before taking a sample. A section of casing with fine slots at the bottom can be used advantageously to let the water enter for the sample. An accurate measurement of the static head can also be obtained. Very often small pipes, screened at the bottom, are placed in some of these holes so that the ground water table can be checked afterward.

With the rotary drill, determining the exact character of the formation is sometimes difficult when a muddy sand or silt which mixes immediately is present. If the hole is enlarged, as when going through a layer of boulders, it is likely that the cuttings will be pumped up to the large section of the hole and the fine sand will be pumped out, leaving the gravel suspended until either the mud is thickened or the velocity of the drilling fluid is increased. A common practice is to stop drilling until the hole is cleaned. By noting how long it takes the cuttings to come out, the well can be properly logged. A rotary drill can be used to decided advantage in testing unconsolidated formations at relatively great depths and where the sand is uniform and it is not necessary to be very particular about the samples. Also, the rotary drill is cheaper and quicker than cable tools when it is desired to find the floor below the sand.

To get a fair, undisturbed sample, one can pull out the drill stem and use

a sampler. A small-size casing, with a screen set in the same way as when cable tools are used, will permit sampling and determining the static head. If a field has been tested with a rotary drill, however, and a few offsets are drilled close by with cable tools for a final check, the differences in samples and logs may prove amazing.

The choice of method in testing unconsolidated formations depends on what information is necessary, the type of material encountered, the depth and the locality.

Consolidated Formations

Deep testing in rock presents entirely different problems. In the first place, the creviced rock and sandstones were probably filled with salt water which was later supplanted by fresh, when conditions became suitable. Some aquifers may be filled with a water very high in chlorides and other minerals. A high head may make it difficult to seal out such water with the methods commonly used. On the other hand, this highly mineralized water may have a low static head and thus will not enter the well or borehole until considerable pumping has caused a drawdown below its static level. This condition partly accounts for the change in water quality noted when the amount or length of pumping is varied. This background should be kept in mind when testing or developing a water supply from a lower aquifer.

When the first water is encountered, drilling should stop and tests should be made for quantity, quality, temperature and static head, the drawdown being determined at the same time. If the water is not adequate or suitable, it may nevertheless be unwise to case it out before drilling further, because the diameter of the hole would be reduced.

Continued drilling may result in a change in head or some other indication of more water. The new head will not be accurate for the lower water encountered, since the figure is affected by the first water, but the change will definitely indicate circulation up or down the hole and into or out of the upper aquifer. After allowing time for exchange, if the circulation is upward, the water sample can be taken on the bailing line, using proper equipment, with fairly good results.

If it is decided to make a pumping test, all the water above the lower level can be sealed out by installing a line of steel pipe from the surface with a few lengths of cast-iron pipe threaded and coupled to the bottom. Where the seal is to be made, the hole can be bridged or a plywood or other suitable disk placed on the bottom of the pipe, together with canvas to hold the cement. Enough cement is then pumped around the cast-iron pipe to make the seal.

After the cement has set, the hole is cleaned out and the pumping test made. A check for drawdown outside of the pipe should be undertaken as this would be an indication of leaks. When the test is complete, the cast-iron pipe can be broken with a perforator or suitable tool, the steel pipe removed, and the cast-iron pipe and cement drilled out. The test drilling can then be continued with no reduction in hole diameter.

This method should be used as each new water-bearing stratum is reached. When the drilling is finished, the water most suitable for use can be determined. The permanent seals can then be placed and the casing set.

The packers employed must be properly placed. Because it is very often difficult to determine where the rock is suitable for a packer, it is much more satisfactory to use cement properly pumped around the pipe. It is very desirable to pressure-grout all casing, if possible. One should keep in mind that the methods used in packing or sealing wells should not permit vertical exchanges with unsuitable waters, a likely occurrence unless adequate precautions are taken to prevent it from happening.

Pumping Tests—*John G. Ferris**

The term "pumping test" appears obvious enough in its implication, but the wide variance in objectives of the many groups now interested in ground water hydrology has resulted in great differences in test procedure. Consequently, there is a need for defining the term in the light of its application by each investigator. In present usage, "pumping test" implies that one or more production wells or a test well is pumped at a rate which may be constant, changing steadily or erratic and that observations are made of the pumping rate, the duration of pumping, the drawdown in the pumped well and perhaps the drawdown in one or more nearby wells. The accuracy with which the changes in pumping rate or water level are measured may range from crude to precise. The frequency of measurement may range from sporadic to continuous. The accuracy in timing the measurements relative to the start, change or cessation of pumping may range from a poor guess to precision. The analysis of the test data may range from qualitative "guesstimates" to quantitative reasoning. As a consequence of these wide differences in pumping test procedure and method of analysis, it is little wonder that reports on the applicability of pumping test results range from misleading to excellent.

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Discharge

The great variations in the geology at different sites make it impractical to outline more than a few detailed specifications for pumping tests. In all tests, the discharge of the pumped well should be maintained at one or more constant rates throughout the test period. If more than one rate is used, the change should be an abrupt step from one rate to another. If the step discharge test is used, the period of pumping for each step should be sufficient to provide the basis for extrapolating water level trends from each past period. The practice of pumping a well "wide open to see what it will do" and then, of necessity, reducing the discharge to prevent breaking suction gives no criteria for determining well yield. Control of the pumping rate is usually effected by a throttling valve on the discharge line, the initial rate being selected to provide ample back pressure for subsequent rate adjustment.

The measurement of discharge may be made by any suitable device that limits the error to less than 5 per cent. Prior to, during and after the test, the pumping from nearby wells which tap the formation being tested should be stabilized. This applies not only to the owner's well system but to all other wells within interference distance. It should be noted that, in some forma-

tions, the interference may be appreciable at distances as great as several miles. If regulation of pumping from outlying wells is not practical, records of their operation should be maintained.

Water Level

The observation of drawdown in the pumped well may be made with a steel tape, altitude gage or electrical device. Although the altitude gage is widely used because of its rugged construction and convenience, it is not well suited to observation of water level unless the changes of stage are large. Errors of several feet may occur if it is used without certain precautions. Such errors may be a considerable proportion of the total drawdown and may exceed the amount of drawdown change during the latter part of the test period. Surging and splashing in the pumping well often make water level measurement by any method difficult and unsatisfactory. Generally, best results in the pumped well are obtained by measuring the recovery of water level after shutdown.

When observation wells are available, water level measurements should be made by steel tape with readings to the nearest hundredth of a foot. Prior to acceptance, each observation well should be tested to determine its sensitivity, either by pumping or by pouring water into the well. In formations that can furnish moderate to large water supplies, a small-diameter observation well should yield or receive 5 gal. of water and return to static in about one minute. If this condition is not met, the well should be brought to this standard by cleaning prior to use.

The spacing of observation wells relative to the pumped well should be based on knowledge of the local geology, the transmission and storage properties of the aquifer, the duration of pumping and the location of nearby pumping activity. Distances may range from less than 100 ft. to as much as several miles. In general, the longer the period of pumping, the greater may be the distance to the observation well. For a given drawdown and a given rate and period of pumping, the greater the transmission capacity of the aquifer, the shorter should be the distance to the observation well. Under the same conditions of drawdown and discharge, the greater the storage capacity or porosity, the shorter the distance to the observation well.

As the drawdown cone is an exponential function, the spacing between wells should be logarithmic. The pattern of observation well distribution should be a pair of right-angle axes with the origin of coordinates at the pumped well. The well line axes should be oriented to conform with known geologic or hydrologic boundaries. For instance, if a stream is entrenched in the aquifer adjacent to the test site, one line of observation wells should parallel the stream course and the other line should extend at right angles to the course and through the pumped well. A similar pattern should be used if the aquifer pinches out along a line such as a steeply rising valley wall.

Timing of Tests

The timing of the pumping test and the frequency of measurement within the test period are of particular importance. If pumping from nearby wells cannot be controlled, it is necessary that the test be run during a period when changes in such extrane-

ous pumping are at a minimum. Like the well spacing, the frequency of observation should be logarithmic. The amount of water level decline at each observation well may be as great during the interval between the first and second minute after starting as between the one-thousandth and two-thousandth minute. Thus, the times of measurement should be very closely spaced at the start of the test or after each change in rate and should decrease in frequency as time progresses. The best guide is to secure almost equally spaced intervals on a plot of the logarithm of time versus drawdown. Good practice dictates that all watches used by the observers should be synchronized with the watch or clock used in starting the pump.

Analysis of Data

The analysis of the test data should be made by accepted methods for the study of disturbances in a potential field as the result of input or output of energy in either the steady or transient state. These methods are discussed in some detail in numerous publications of the federal and state geological survey agencies and the technical societies, and in textbooks on physics, heat flow, electricity and hydrology. Although these methods are of relatively recent application in hydrology, they are of long standing and proved value in other fields of science.

In Michigan, in the past few years, several consulting engineers, a geophysicist and a well-drilling contractor have adopted and now use as standard practice the above methods of pumping test procedure and analysis. Examining their experiences, many striking examples of the practical utility of these methods are found. One well was drilled in a rock formation at a site selected by a consulting engineer on the basis of pumping test and geologic data from nearby wells, but without recourse to a test hole at the specific site. It was predicted that a well could be developed which would produce 1,000 gpm. with a drawdown of less than 10 ft. after four hours of pumping. This procedure of drilling the production well without a prior test hole at the site was questioned by the drilling contractor. His impressions of the materials encountered in the test well led him to predict the final well would not meet the specifications. He was surprised and pleased when, in the acceptance test, the well produced the estimated 1,000 gpm. at the specified drawdown.

Another consulting engineer specified, ordered and delivered to the job a deep well turbine pump for a production well before drilling of the well was started. The pump size had been determined on the basis of a pumping test on a test hole of smaller diameter about 100 ft. from the final well site. From the knowledge of the aquifer capacity thus obtained, it was possible to calculate the yield and drawdown for a proposed well for different pumping periods. It was predicted that the proposed well would yield 1,000 gpm. with 19 ft. of drawdown at the end of four hours. The measured drawdown in the final well at the 1,000-gpm. rate was 18.7 ft. at the close of the four-hour test period.

Properly conducted and interpreted, the pumping test provides the means for translating the inferences of geology and geophysics, relating them to the results of the test drilling and appraising all the information in a quantitative manner which furnishes the

engineer with the basic data necessary for the design of wells and well systems. Thus, an economic study can be made of the relative importance of diameter, spacing and distribution of wells in any aquifer, as well as a prediction of interference effects and extent of liability to the wells of adjoining owners, and a determination of long-range performance.

Designing for the Future—*John J. Baffa*

Today more than ever ground water prospecting procedure must include the element of designing for the future. The nation's ground water resources are a precious heritage which should be intelligently used and not abused. Abuse by overdraft, pollution, well interference and waste represents economic loss. Intelligent use of ground water requires regulation based on the past record and future history of the overall water resources of the watershed or area, with due cognizance of the hydrologic relations between surface and subsurface waters. The dynamic balance which is called ground water flow should not be governed by static regulations.

Ground Water Economy

The water resources of any watershed or area which are available for human consumption consist of the two major items of surface and ground water. They can be likened to two parallel economies for the furnishing of water to mankind, and they are related portions of nature's great holding company, the hydrologic cycle. Each may have a monopoly in certain areas, while in others their destinies are inextricably interwoven, so that streams, lakes, ponds and reservoirs may be able to supply continuous beneficent recharge to ground water or high surface water stages may pollute lower-level ground waters. On the other hand, stream flow during low-runoff periods is maintained at usable levels entirely by ground water effluent seepage. These exchanges of assets have been reduced to quantitative entities on various watersheds by the excellent work of the U.S. Geological Survey forces.

In order to maintain the ground water economy at solvent levels intelligently, it is necessary to study its balance sheet of assets and liabilities. In so doing, water can be considered the medium of exchange.

On the assets side of the ledger, the first entry is "cash on hand," defined as water in storage above a level at which optimum usable recharge is possible while at the same time economic losses to important stream flows will not be induced. Quantitative estimates of this item must be computed with due cognizance of the principle of specific yield.

The second entry on the assets side of the ledger is "accounts receivable," including: [1] rainfall and snow-melt penetration to the zone of saturation (equal to precipitation minus evaporation, transpiration and runoff); [2] natural influent seepage from streams, lakes and ponds; [3] artificial influent seepage from irrigation, reservoirs, spreading and recharge; and [4] inflow from free or confined ground water.

The third asset is the "cash reserve," that is, the water in storage below the level of "cash on hand." The continuing depletion of this reserve results in ever increasing pump lifts, lack of

stream flow sustenance and ultimate failure.

On the liabilities side of the ledger there are a number of "accounts payable." These are: [1] development pumping, [2] artificial removal by drainage systems, [3] effluent seepage to streams and springs, [4] evaporation of free ground water, [5] transpiration losses and [6] subsurface discharge of free or confined water.

In a natural state, there is a dynamic balance of assets and liabilities. When man disturbs this balance by ground water development, it is his earnest desire to obtain a perennial supply. He must recognize, however, that nature has placed ceilings on the total available assets and gives no credits for the payment of natural debts. Development is limited, too, by nature's ceilings on rates of withdrawal of assets.

The lowering of levels by overdraft will result in stream flow losses and higher pumping heads and may lead to reduced yield and contamination. When contamination by salt water or manmade pollution occurs, the medium of exchange becomes counterfeit. If development pumpage exceeds the total of accounts receivable, the cash on hand may be used up quickly, and, with expenditures exceeding income, it may be necessary to dip into the cash reserve. Under such conditions, only ultimate bankruptcy is in view unless optimum degrees of development pumping are maintained.

On the other hand, it may be economically feasible to obtain sustained solvency with artificial recharge or controlled natural recharge by surface water regulation. Considerable expenditure may often be justifiable for recharge structures and operations, and for control of vegetative cover, in the interests of increasing natural percolation to the zone of saturation, returning unpolluted waters to storage, diverting surplus stream flow to ground water storage, preventing contamination and augmenting stream flows during periods of little or no surface runoff. The natural debt which must be paid to maintain stream flows should be recognized in many areas. There is no profit in nature's total economy.

There are, of course, many possible degrees of economical, safe utilization, depending on the particular circumstances. The application of quantitative values to the balance sheet items requires the study and interpretation of all available data of record and all necessary field and laboratory measurements. The differences between water table and artesian conditions must be given due consideration. The most practical quantitative measure is the recorded correlation of rainfall, borehole levels and development pumpage.

The most powerful tools for designing for the future in the interests of maintaining a solvent ground water resource economy are found in the sciences of meteorology, geology and ground water hydraulics.

Role of Meteorology

The ground water assets of any area are basically derived from precipitation, so that the role of meteorology is of extreme importance. It controls the source of the accounts receivable item of the ground water balance sheet. In the current inventory being made of the nation's water resources, meteorologists will be called upon to indicate areas of bountiful or deficient rainfall and to apply the powerful tools of statistical analysis to estimate future me-

teorological history. This is exploration on a grand scale.

In designing any ground water supply for the future, it is necessary to estimate the amount of precipitation that will fall on the recharge area, as well as its distribution and variations. The percentage of precipitation available for recharge is related to climatic conditions, vegetative cover and geological considerations. The excellent, long-term records of the U.S. Weather Bureau provide abundant precipitation data for statistical analysis. An outstanding example of this technique is the current operation of the multiple-purpose structures of TVA based on quantitative precipitation forecasts. There is evidence, too, of a high percentage of successful long-term quantitative predictions based on the sunspot theory of cyclic occurrences. In the author's opinion, many important water supplies should be examined in the light of the writings of Halbert P. Gillette (1), who has presented proof of cyclic drought occurrence founded on geologic evidence contained in stratified rocks and on other data.

There has been evidence in the past few years that man, in his persistent invasion of nature's secrets, has attained the ability to make rain and thus speed up the hydrologic cycle in order to return to earth, when required, the water that is stored in the atmosphere. Further developments in rainmaking will be awaited with interest by the profession. In its application to ground water considerations, rainmaking would have to be considered from the standpoint of actual recharge availability.

Although precipitation represents the source of the accounts receivable item in the ground water economy, meteorology alone cannot reveal the actual amount of this asset and the characteristics of its availability, not only to the recharge area and to the zone of saturation, but also to producing wells. Therefore, in estimating and designing for the future, geology and ground water hydraulics have a vital function.

Geology and Ground Water Hydraulics

The earth has varying capacities to receive and store rainfall and to allow it to flow laterally to areas of development and natural discharge. Thus, there are natural ceilings on the rate of receiving assets and the rate at which they can be utilized. To apply quantitative values to these items, it is necessary to know the geologic conditions that affect the occurrence and quality of ground water, the extent and dip of aquifers, the character of overburdens, the existence of natural barriers to ground water flow and the nature of rock interstices as related to the geologic agencies which have produced them. Geology defines the occurrence and structure of the containing medium.

In the current water resources inventory, the federal and state geological survey organizations will be called upon to indicate areas of ground water occurrence and the factors influencing its availability. This, too, is exploration in its broadest sense. The excellent records of these agencies—comprising subsurface maps, characteristics of aquifers, water level histories, and correlations of rainfall, runoff, ground water flow and pumpage, and water requirements of vegetation—have resolved all ground water problems of importance. The members of these agencies have contributed most to the developments in ground water

hydraulics. It is mandatory that such activities be continued and amplified.

With the mapped framework of a natural underground water system at hand, and with knowledge of the character of its interstices, it is possible to compute its storage capacity and its capacity to transmit water from intake area to well field—based on test drilling, sample analyses and pumping tests—and also to determine the required well spacing and the details of well design for various rates of draft. Of outstanding consequence in the development of knowledge concerning ground water hydraulics was the publication in 1935 by C. V. Theis of the nonequilibrium formula for the computation of coefficients of storage and transmissibility (2). Of recent note is John G. Ferris' application of the image method to the interpretation of local geology from pumping test data (3).

The application of these principles to geologic and pump test data quantitatively defines nature's ceilings on the rate of withdrawal of assets from the aquifer as a whole and in the vicinity of a pumping well. The need for proper consideration of the localized effects of development on extensive aquifers under water table and artesian conditions is emphasized. Current U.S. Geological Survey researches on the effects of vertical variations in aquifer permeability will prove of great value in allowing refinement of estimates of transmissibility and well yield.

Conclusion

The utilization of the methods of ground water prospecting described in this panel discussion is providing more data for the record in many areas, and, thus, furnishing information and knowledge for the application of quantitative values to designing for the future.

The author has purposely not used the words "safe yield" throughout this discussion. It is suggested that thinking be directed toward "safe utilization" of total water resources. It is also recommended that the sciences of hydrology and hydro-meteorology and the basic principles of statistics be given greater weight in engineering curriculums. In designing for the future, the natural underground water systems must not be taxed out of existence.

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Relation Between Municipal and Industrial Water Treatment

By J. N. Welsh

A contribution to the Journal by J. N. Welsh, Assoc. Director, Hall Labs., Inc., Pittsburgh, Pa.

THE average water works operator is prone to consider that he has done his job when he delivers to the mains a water which is palatable, safe to drink and otherwise satisfactory for use in the home. His attitude is that, if water for industrial purposes needs further treatment, industry should provide it. Industry may be an important and profitable customer, however, if a basis for mutual cooperation can be worked out. The water works automatically benefits industry by employing procedures such as clarification and partial softening, but an analysis of all the economic factors involved might indicate that additional softening, for example, would be worth while. In short, there seems no reason why the water works should not give the greatest possible consideration to industry's requirements in planning the treatment of water for domestic use.

Industrial Water Use

Figure 1 is a schematic diagram showing the path of water in industrial plants. "Preliminary General Processing" includes the treatment given at the municipal plant to produce the clear, palatable, safe water previously mentioned, even though such processing is often accomplished individually by industrial plants. In fact, industry requires many of the same treatment processes as are used in preparing potable water, but to different degrees for different specific purposes.

As indicated by the diagram, the water, upon reaching the industrial consumers, follows two general paths, one involving uses in which evaporation (change of phase) does not occur and the other involving uses in which it does. The water is already in satisfactory condition for many uses in the first category, since it is suitable for drinking, but numerous plant processes require additional treatment, such as softening or demineralization. Successful use in a once-through cooling system may require stabilization for prevention of calcium carbonate deposition, treatment for control of corrosion in piping and heat exchangers or additional chlorination for control of microorganisms. Even in restaurants, which may be looked upon as small industrial consumers, special treatment is necessary for use in mechanical dishwashers. On the whole, however, the problems encountered are relatively simple.

Where change of phase is involved, the problems are more difficult. Concentration in recirculating cooling systems may necessitate microorganism control with biocides, softening, stabilization with complex phosphates

(sometimes supplemented with acid treatment to prevent deposit formation) or the application of chemicals for control of corrosion.

This division of the diagram also relates to the use of water for generating steam, at all temperatures and pressures up to the critical—705°F. and 3,206 psi. (superheating of steam extends the temperature range to 1,000–1,100°F.). In this process, water of varying purity is introduced into the steam generator and the "pure" steam is withdrawn, leaving behind the concentrated boiler water or brine containing all impurities except those volatilized. Concentration is limited by the blowdown of boiler water or brine. In a salt-water evaporator on shipboard, operating at subatmospheric pressure, the brine may represent 1.5 concentrations of ocean water or a concentration of approximately 50,000 ppm. On the other hand, in a typical steam boiler generating 850,000 lb. of steam per hour at 1,400 psi. and driving an 85,000-kw. turbogenerator 24 hours a day for months on end without interruption, feedwater is all condensate and evaporated makeup, and the concentration of dissolved solids in the boiler water amounts to 200 ppm. or less, blowdown being merely a trickle. In between the low-pressure evaporators and the high-pressure steam generators using distilled water as feed, there are the myriad boilers operating at high and low pressures and steam temperatures, generating a few hundred to 1,000,000 lb. of steam per hour and using varying percentages of raw or treated water as makeup in the feedwater. All, including the low-pressure evaporators and high-pressure generators receiving all condensate as feedwater, require that the makeup water be suitably pretreated and that proper attention be given to conditioning the boiler water or brine. Pretreatment may embody clarification, softening, silica removal, alkalinity reduction, removal of carbon dioxide (free and fixed), demineralization and oxygen removal. Conditioning of the concentrated boiler water or brine embodies careful control of the concentrations of phosphate, alkalinity, silica and total solids at levels satisfactory for the equipment in use and the operating conditions to be dealt with. It may involve the use of sodium nitrate, potassium salts, sodium sulfite, dispersive agents or antifoams. Conditioning is essential if troubles with deposit for-

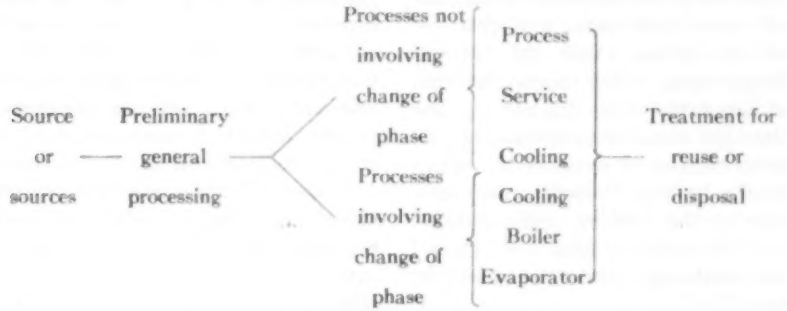

FIG. 1. Path of Water in Industrial Plants

mation, corrosion, carryover and embrittlement are to be avoided.

The last division of the diagram, "Treatment for Reuse or Disposal," puts the shoe on the other foot. Industry, in a sense, affects the raw material with which the water plant operator must work, because the contamination of surface supplies with industrial waste influences the color, taste and odor of the potable water produced. Therefore, industry can help the water works operator by cleaning up waste water before discharging it to the sewer.

It would be interesting to delve further into the relationship between municipal water treatment and that required to make water fit for all industrial uses. The object of this paper, however, is to discuss the use of water for steam generation—not all of the intricacies of treating the water within the boilers, or before its introduction to the boilers, but, broadly, some of the factors which are affected by the treatment given the water at the municipal plant.

Suspended Matter

Silt is a normal contaminant of surface waters, particularly during periods of heavy runoff, and its presence in ground waters is not uncommon. It is composed largely of siliceous matter such as clay, decaying vegetable matter and iron oxide. When present in significant amounts, its removal from water to be used as boiler feed is essential for physical as well as chemical reasons.

If the pretreating equipment in the steam-generating plant is of the ion-exchange type, the silt and other suspended material must be removed before the passage of the water through the equipment; otherwise, loss of capacity will ensue because of fouling of the exchange material. If the raw water is used in the boilers, failure to remove silt will increase the suspended-solids, silica and aluminum concentrations of the boiler water. If pretreatment is with lime and soda ash in a cold-process softener, the removal of reasonable amounts of suspended matter is compatible with simultaneous reduction of hardness since the water temperature is low enough to obviate significant dissolution of silica and aluminum from the suspended matter, even though the alkalinity of the water is relatively high. In hot-process equipment, however, conditions of temperature and alkalinity are such that dissolution of considerable silica and aluminum from silt can seriously interfere with the maintenance of optimum conditions in the boiler water.

Under certain conditions dissolved aluminum in boiler water can result in the formation of sodium aluminum silicate scale at the evaporative surfaces. Silica, complex silicates, or magnesium phosphate may form deposits in the boilers, and silica deposition on turbine blades may also occur. Boiler water silica concentration must be controlled at varying levels, depending upon factors such as operating pressure, rating, boiler design, slagging of furnaces, uses of steam and relative concentrations of other boiler water constituents.

The difficulties that can be encountered through failure to remove suspended matter from boiler feedwater are illustrated by the experience of a Maryland chemical plant (1). For ten years this plant waged a discouraging and unsuccessful battle against the formation of sodium aluminum silicate scale in boilers producing 120,000 lb.

of steam per hour at 600 psi. The fundamental cause of the trouble was recognized to be clay in the well water used. In the absence of clarification equipment, futile efforts were made to improve the quality of the boiler feedwater by repairing well strainers, abandoning the use of water from some wells and making up the deficiency in supply with city water, recovering more condensate, and changing chemical conditions in the boiler water. Finally, when increased steam consumption required the installation of an additional boiler, it was decided to include suitable pretreating equipment, the most important part of which was for preliminary coagulation and filtration. Subsequent operation for more than three years has proved the wisdom of this move, since there has been no further development of complex-silicate scale.

Where does the water works fit into this picture? Filtration, or coagulation-filtration, is one of the most common procedures employed in the treatment of municipal water. Suspended solids are removed from the water, and the dissolved-solids concentration is not materially increased unless heavy burdens of suspended or organic materials require large dosages of coagulating chemicals. Obviously, such clarification is a boon to the industrial consumers using the water for steam generation, since otherwise many would have to do the job themselves.

A word of caution is in order. In using aluminum sulfate, or other aluminum-bearing salts for coagulation, the municipal plant can benefit industry by giving attention to the dissolved-aluminum concentration in the filtered water and making every effort to keep it at a minimum. This is important to those plants using the municipal water for boiler feed.

Organic Coloring Matter

There are differences in the types of organic coloring matter which are naturally present in many water supplies. Also, there are variations in the effects produced in boiler water. Certain kinds of coloring matter decompose in the hot, alkaline boiler water to form compounds which cause foaming and carryover (*2*). If there is localized evaporation practically to dryness in boilers, decomposition of organic matter at these locations can produce relatively insoluble organic compounds which contribute to the formation of deleterious deposits. Finally, organic matter with dispersive properties will seriously interfere with hardness removal in hot-process softeners. This difficulty is particularly noticeable in numerous Canadian river waters, where the softer, highly colored water representative of spring freshets does not respond to treatment in hot-process lime-soda softeners.

What can eventuate if the effects noted are ignored is well demonstrated by the experience of a large southern paper mill. During construction, more than ten years ago, the engineering department was duly warned that, before being used in the new high-pressure, high-capacity boilers, the soft, highly colored river water available should be freed of contaminating organic matter. Economic conditions were such that expenditures for equipment had to be held to a minimum. For this reason, the warning was not heeded and the boilers were placed in service with no provision for pretreatment of makeup water. The plant was in trouble immediately. Foaming and

carryover of boiler water in the steam were so severe that the operation of the whole plant was endangered because of fouling of superheaters and turbines with deposits. Fortunately, frequent cleaning of superheaters and turbines permitted operation to continue and, eventually, suitable clarification equipment was installed.

From the standpoint of the water works, color is high on the list of undesirable components in water. Removal is usually accomplished by coagulation and filtration, but simple chlorination can be somewhat helpful and free residual chlorination or superchlorination is decidedly beneficial. Regardless of the procedure used for color removal, the municipal water works performs a real service to the industrial plant using the water in boilers.

Hardness and Carbon Dioxide

In many areas where the water available is very hard, the municipal plants are equipped for softening with lime, lime and soda ash or ion exchangers. Attention is directed principally to getting a certain amount of hardness removal, and little or no consideration is given to the final amount of carbon dioxide in the water. Since both factors are important to the industrial steam-generating plants, and since they are very closely related because of the softening procedures used by the municipal plants, they will be discussed together.

On the whole, the water works is not interested in reducing hardness much below 100 ppm., as calcium carbonate. Still, the net effects are good from the standpoint of the consumer who requires the water for steam generation, because many small, low-pressure plants can use the water economically without further pretreatment, employing chemical conditioning of the boiler water with satisfactory results and at reasonable cost. Even large, high-pressure plants, which must do additional pretreating, will spend less for chemicals to treat the partially softened municipal water than to treat the very hard natural water, and possibly will find the capital expenditure for the necessary pretreating equipment to be appreciably lower.

The water works operator does not ordinarily think of the effect of softening on the potential carbon dioxide concentration of steam generated from the treated water. Carbon dioxide in steam dissolves, at least in part, in the water produced by condensation, thus reducing the pH value of the condensate and leading to corrosion of heat exchangers and piping which come in contact with the condensate. Without reviewing the theories of corrosion or contemporary procedures for reducing carbon dioxide concentration of steam, suffice it to say that the concentration should be as low as possible (3).

Sources of carbon dioxide in steam are dissolved carbon dioxide, bicarbonates and carbonates in the boiler feedwater, and sodium carbonate which is frequently fed to boilers to produce the desired alkalinity in the boiler water. Dissolved carbon dioxide, if not removed from the boiler feedwater in an open or deaerating type of heater, will be driven out of the boiler water into the steam. At the temperature of the boiler water, bicarbonate will decompose completely to form carbonate, with liberation of carbon dioxide, and then hydrolysis of carbonate present as sodium carbonate will produce hydroxide in the water, freeing additional carbon

dioxide in the steam. It should be borne in mind that, if no phosphate is used in the water of low-pressure boilers, the carbon dioxide concentration of the steam will be minimized by precipitation of much of the carbonate as calcium carbonate. On the other hand, phosphate conditioning, which is essential for the prevention of scale formation at pressures in excess of about 150 psi., will result in precipitation of calcium phosphate, and the sodium carbonate produced by the reaction will be free to hydrolyze and liberate its carbon dioxide content.

Thus, in softening waters high in temporary hardness with lime, municipal plants automatically render double service to the consumers using the water for steam generation without further pretreatment. The removal of free carbon dioxide and substantial reduction of bicarbonate concentration with the lime result in lowering the potential carbon dioxide concentration of the steam produced by the boilers. In addition, the use of an expensive chemical like cyclohexylamine (4), which is employed to reduce corrosion in return lines by neutralizing the carbon dioxide and increasing the pH value of the condensate, might be rendered economical, whereas consumption would be too great with the natural water being fed to the boilers. A rough idea of the significance of this point can be obtained from the fact that approximately 2 ppm. of the chemical is required to neutralize 1 ppm. of carbon dioxide and that the cost of the pure chemical is on the order of 90¢ per pound.

Water partially softened by means of lime or lime and soda ash is sometimes stabilized by recarbonation. This will minimize the formation of calcium carbonate or magnesium silicate deposits in the boiler feedwater heaters, since the lower the pH value of the water, the less danger there is of precipitation of these compounds when the water temperature is increased to more than 200°F. The procedure does, however, augment the carbon dioxide concentration of steam produced from the water.

A somewhat similar situation results from the practice of increasing the pH value of water to control "red water." The addition of lime raises the hardness of the water and thus increases chemical consumption in boiler plants. Soda ash does not have the same effect on hardness, but it does increase to some extent the amount of carbon dioxide in the water that can be released in the steam.

As far as hardness is concerned, sodium ion-exchange softening has the same beneficial effects in steam plants as lime or lime-soda softening. Such ion-exchange treatment, however, leaves all the free carbon dioxide and bicarbonate in the water and, thus, from the standpoint of the steam-generating plant, it is inferior in this respect to lime or lime-soda treatment where the raw water is high in temporary hardness. There are other considerations, too. Since ion-exchange treatment in the sodium cycle does not affect the bicarbonate concentration of the water, waters high in temporary hardness, when so treated, contain sodium bicarbonate alkalinity which, if appreciable in amount, will produce high alkalinity in the boiler water unless heavy blowdown is given the boilers. The choice of pretreating equipment, in steam plants requiring it, is also affected by partial ion-exchange softening, since the equipment best

suited to the removal of sodium bicarbonate from the water can be entirely different from that for the removal of temporary hardness. No general conclusions will be drawn since the selection of equipment must be based upon individual plant requirements.

Ammonia

Water polluted with sewage or certain types of industrial waste can contain substantial amounts of ammonia, as well as albuminoid nitrogen which is potential ammonia in the steam from boilers. Exactly what concentration of ammonia in steam should be considered dangerously high is controversial, especially if dissolved-oxygen removal at the deaerating heater is so effective that the remanent concentration in the feedwater is no more than a slight trace. Nevertheless, every bit of ammonia present in the water fed to boilers will be driven off in the steam and, if the concentration in the steam is greater than about 1 ppm. in excess of that required to combine as ammonium bicarbonate with any carbon dioxide present, serious and costly damage can ensue at points where there is condensation of steam in contact with copper or copper-bearing alloys (5). In an Ohio steel plant using badly contaminated river water in the boilers, samples of condensed steam have been found to contain as much as 26 ppm. ammonia. Even with less than 1 ppm. in the steam, a large Pennsylvania steel plant experienced serious loss of copper-bearing alloy tubes in an air ejector condenser because of accumulation of ammonia to a concentration of more than 80 ppm. in the condensate.

Free residual chlorination or superchlorination at the water works will practically eliminate difficulty of the character described in industrial plants using the city water, since the process will destroy all, or almost all, of the ammonia in the water. The chlorine residual must be closely controlled, however, or else trouble can occur in steam plants where the boiler feedwater is pretreated in exchangers of the carbonaceous or resinous type. These, with the exception of some of the newer polystyrene base resins, are sensitive to chlorine because of its powerful oxidizing property (6). Thus, dechlorination with a chemical such as sodium sulfite is necessary to prevent intolerable loss of exchange material, unless the chlorine concentration of the water to be treated is less than about 0.5 ppm.

Another aspect of chlorination is the use of ammonia in conjunction with chlorine to form chloramines. If the amount of ammonia is of sufficient magnitude, it can be a source of worry in steam power plants where the boiler feedwater is condensate and evaporated makeup, and where a determined effort must be made to keep the ammonia concentration of the steam at a minimum for the protection of condenser and closed-heater tubes. In a certain large utility plant, approximately 1 ppm. of ammonia showed up in the steam following the institution of chloramine treatment of the city water, which was used in the evaporators. Although it was found possible to obtain significant ammonia reduction by discarding drips from the after condensers, this procedure meant wasting normally good condensate.

Oxygen

The great majority of the effluents from municipal water plants contain

substantial quantities of dissolved oxygen, which is not of undue concern to boiler plants using the water because it is a normal condition and the plants are usually set up to handle water containing dissolved oxygen in concentrations up to saturation (7). In fact, aeration at the water works often helps the boiler plant. The process is frequently used in connection with the removal of iron and manganese from ground waters high in these constituents. In other instances, waters are aerated to remove dissolved gases such as carbon dioxide or hydrogen sulfide, or to destroy anaerobic bacteria. All in all, the net effect is beneficial and not harmful.

An unusual situation where aeration actually did react unfavorably is interesting and enlightening. A California paper mill which employs low-pressure evaporators to supply distilled water for the boilers uses well water from the town mains as evaporator feedwater. The water, which is high in temporary hardness, is treated with cation exchanger, but not deaerated, before being fed to the evaporators. For more than ten years there was no trouble whatever in the evaporators, but suddenly corrosion of the arsenical-copper coils began to occur, and, in six months, the attack was severe enough to result in perforation. Thorough study of the problem led to the conclusion that oxygen, in conjunction with the large amount of carbon dioxide being driven out of solution around the coils because of the decomposition of sodium bicarbonate, was responsible for the corrosion. This theory was proved by feeding sodium sulfite to fix the oxygen in the evaporator water, whereupon the attack on the coils was arrested immediately. There still remained the question of why the plant was able to operate so long without trouble. Clarification of the picture came a little later when it was learned that the water works had installed aerating equipment to eliminate anaerobic slimes in the distribution system, the date the new aerator was placed in operation coinciding with the date corrosion of the copper coils began.

Phosphate

Small amounts of complex phosphate are used by many municipal water plants to stabilize lime- or lime-soda-treated waters, to control corrosion or to control iron and manganese precipitation (8,9). The first two procedures normally involve the addition of 1 or 2 ppm. of complex phosphate to the water at the water works. The last procedure applies principally to ground waters, to which the phosphate chemical can be added in appropriate amounts before the water comes in contact with oxygen or some other oxidizing agent, such as chlorine. The usual amount fed is two parts per part of iron or manganese.

The detrimental effects of the procedures described are more or less limited to interference with proper softening in plants pretreating boiler feedwater in cold-process, lime-soda softeners. This difficulty can be overcome by using a coagulant in the softeners to adsorb the complex phosphate. The beneficial effects include corrosion protection in the boiler plant piping and prevention of fouling of exchange material in ion-exchange softeners with iron oxide, either by the precipitation of dissolved iron or by the corrosion of the piping and the carrying of the corrosion product along with the water.

The preliminary use of complex phosphate by the water works may slightly reduce phosphate consumption in the steam-generating plants employing the chemical for boiler water conditioning. Such reduction is normally not of great moment. In one plant, however, city water, with about 2 ppm. of complex phosphate added for corrosion control, is used in the boilers after pretreatment in cation-exchange softeners. The operation of the softeners is so carefully controlled, and the effluent is so soft, that no supplementary phosphate feed is necessary, the small amount already present in the city water being sufficient to produce the desired concentration in the boiler water. Remarkable as it may seem, in this instance, the water works is supplying all of the phosphate needed by the boiler plant for boiler water conditioning.

Conclusion

Although the primary aim of the water works operator is to give the domestic consumer a safe, clear, palatable water which will not plug hot-water heater coils, ruin the wash or rapidly corrode steel water pipes in the home, the operator should not overlook the importance of industrial consumers and should win their gratitude and support by doing anything economically feasible to make the water better for their purposes.

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American Water Works Association

Tentative
STANDARD SPECIFICATIONS
for
FERROUS SULFATE

These "Tentative Standard Specifications for Ferrous Sulfate" are based upon the best known experience and are intended for use under normal conditions. They are not designed for use under all conditions and the advisability of use of the material herein specified in any water treatment plant must be subjected to review by the chemist/engineer responsible for operations in the locality concerned.

Approved as Tentative by the Board of Directors of the A.W.W.A. on May 31, 1949

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Tentative
Standard Specifications for Ferrous Sulfate

Part A—Material Specifications

Sec. 1A—Scope

These specifications cover ferrous sulfate, either granular or lump, for use in the treatment of municipal and industrial water supplies. The specifications are intended for use in connection with Part B (Sampling, Inspection, Packing and Marking) and Part C (Testing Methods) of this document.

Sec. 2A—Definition

Ferrous sulfate is the product of the reaction between sulfuric acid and iron and is usually the by-product of the "pickling" operation. It is commonly known to the trade as "copperas" and, in the granular form, as "sugar sulfate of iron."

Sec. 3A—Sampling

Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing and Marking) of this document.

Sec. 4A—Methods of Testing

The laboratory examination shall be carried on in accordance with Part C (Testing Methods) of this document.

Sec. 5A—Impurities

The ferrous sulfate supplied under these specifications shall contain no soluble mineral or organic substances in quantities capable of producing deleterious or injurious effects upon the health of those consuming the water which has been treated properly with ferrous sulfate.

Sec. 6A—Rejection

6A.1. Notice of dissatisfaction with a shipment, based on the specifications, must be in the hands of the consignor within ten days after receipt of the shipment at the point of destination. If the consignor desires a retest, he shall notify the consignee within five days of notice of the complaint. Upon receipt of the request for a retest, the consignee shall forward to the consignor one of the sealed samples. In the event that the results obtained by the consignor, on retesting, do not agree with the results obtained by the consignee, the other sealed sample shall be forwarded, unopened, for analysis to a laboratory agreed upon by both parties. The results of the referee analysis shall be accepted as final and the cost of the referee analysis shall be paid for by the party whose results show the greatest discrepancy from the referee results.

6A.2. On the basis of the retest or the referee test, the consignor may remove the material from the premises of the consignee or a price adjustment may be agreed upon by the consignor and consignee.

Sec. 7A—Size

7A.1. Granular ferrous sulfate shall be of such size that not less than 90

per cent shall pass a National Bureau of Standards No. 10 sieve having 9.21 openings per linear inch, and 100 per cent shall pass a No. 4 sieve having 4.22 openings per linear inch.

7A.2. Lump ferrous sulfate shall range in size from not less than ¾ in. to not more than 3 in.

7A.3. Granular ferrous sulfate shall be clean and free from all dirt and particles of foreign matter.

Sec. 8A—Chemical Composition

8A.1. Ferrous sulfate, granular or lump, shall contain not more than 1.0 per cent of insoluble matter.

8A.2. Either form of ferrous sulfate shall contain not less than 19.5 per cent of available iron.

8A.3. Either form of ferrous sulfate shall contain not more than 0.04 per cent of free sulfuric acid, expressed as H_2SO_4.

Part B—Sampling, Inspection, Packing and Marking

Sec. 1B—Scope

These procedures for the sampling, inspection, packing, weighing and marking of ferrous sulfate are intended for use in connection with Part A (Material Specifications) and Part C (Testing Methods) of this document.

Sec. 2B—Sampling

2B.1. Samples shall be taken at the point of destination.

2B.2. If the ferrous sulfate is handled by conveyor or elevator, a mechanical sampling arrangement may be used.

2B.3. If the material is packaged, 5 per cent of the packages shall be sampled. No sample shall be taken from a broken package.

2B.4. If the ferrous sulfate is in lump form, representative pieces shall be taken from the bulk shipment or the packages, taking care to avoid including a disproportionate amount of the material from the top or bottom.

2B.5. Ground ferrous sulfate may be sampled, by the use of a sampling tube which is at least ¾ in. in diameter, from carload shipments in bulk or from packages.

2B.6. The gross sample, weighing at least 10 lb., shall be crushed if necessary, mixed thoroughly and quartered to provide three 1-lb. samples. These shall be sealed in airtight, moistureproof glass containers. Each sample container shall be labeled to identify it and the label shall be signed by the sampler.

Sec. 3B—Packing and Shipping

3B.1. Ferrous sulfate may be shipped in bulk, in 100-lb. multiwalled, moistureproof paper bags, in 200-lb. textile or burlap bags or in 400-lb. barrels, as may be specified.

3B.2. The net weight of packages shall not deviate from the recorded weight by more than 2.5 per cent, plus or minus. If exception is taken to the weight of the material received, it shall be based on a certified unit weight of not less than 10 per cent of the packages shipped, selected at random from the entire shipment.

Sec. 4B—Marking

Each shipment of material shall carry with it some means of identification. Each package shall have marked legibly thereon the net weight of the contents, the name of the manufacturer and a brand name, if any. The package may bear also the statement "Guaranteed by (name of manufacturer) to meet the specifications of the American Water Works Association for ferrous sulfate."

Part C—Testing Methods

Sec. 1C—Scope

These methods for the examination of ferrous sulfate are intended for use in connection with Part A (Material Specifications) and Part B (Sampling, Inspection, Packing and Marking) of this document.

Sec. 2C—Sampling

2C.1. Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing and Marking) of this document.

2C.2. The sample delivered to the laboratory shall be quartered to approximately 200 g. and this amount reduced by mechanical grinding, or in a mortar by hand, to such size that all of it passes a 30-mesh sieve. After thorough mixing, this sample should be stored in an airtight glass container and weighed out of it rapidly to avoid change in moisture content.

2C.3. The laboratory examination of the sample shall be completed within five working days after receipt of the shipment.

Sec. 3C—Insoluble Matter

3C.1. *Reagent.* 1 per cent sulfuric acid in distilled water.

3C.2. *Procedure.* Dissolve 5 g. of the sample in 150 ml. of acidified distilled water. Filter through a Gooch crucible and wash the residue with several portions of acidified distilled water until sulfate free. Transfer the filtrate to a 500-ml. measuring flask and make up to the mark. Dry the Gooch crucible to constant weight at 100°–150°C.

3C.3—*Calculation:*

$$\frac{\text{Weight of insoluble residue}}{\text{Weight of sample}} \times 100 = \text{per cent insoluble matter}$$

Sec. 4C—Total Soluble Iron

4C.1—*Reagents:*

4C.1.1. The following reagents are used regardless of which reduction method is employed:

(a) 25 per cent phosphoric acid

(b) 0.3 per cent diphenylamine barium sulfonate

(c) Approximately 0.1*N* potassium dichromate (dissolve 4.903 g. of the recrystallized dehydrated salt in 1 liter of distilled water; allow the solution to stand a few hours before standardization; standardize against Sibley iron ore furnished by the National Bureau of Standards using either the zinc or stannous chloride reduction method)

4C.1.2. In the *zinc reduction method,* the following reagents are used:

(a) 10–20-mesh, iron-free, granulated zinc

(b) 1 : 3 iron-free sulfuric acid

4C.1.3. In the *stannous chloride reduction method,* the following reagents are used:

(a) Saturated solution of mercuric chloride

(b) Stannous chloride (dissolve 5 g. of stannous chloride in 10 ml. of concentrated hydrochloric acid and dilute to 50 ml. with distilled water; add a few pieces of metallic tin; this solution keeps best in the refrigerator)

(c) Concentrated hydrochloric acid

4C.2—*Procedure:*

4C.2.1. After thoroughly mixing the filtrate from the determination of the insoluble matter (3C.2), pipet 100-ml. portions of this solution into 250-ml. Erlenmeyer flasks for reduction by the zinc or stannous chloride method.

4C.2.2. *Zinc reduction method.* Add exactly 1 g. of granulated zinc and 20 ml. of diluted sulfuric acid and close the mouth of the flask with a

Bunsen valve. Heat gently. The zinc should not be dissolved in less than 25 minutes. After the zinc has been dissolved, boil gently for five minutes and cool to room temperature with the Bunsen valve in place. Rinse the Bunsen valve with distilled water, add 30 ml. of 25 per cent phosphoric acid and seven to ten drops of diphenylamine barium sulfonate indicator. The total volume of the solution should be between 150 and 200 ml.

4C.2.3. *Stannous chloride reduction method.* To the solution in the Erlenmeyer flask (4C.2.1) add 10 ml. of hydrochloric acid and heat to boiling. Add the stannous chloride solution dropwise until the last trace of greenish-yellow color disappears. Then add one additional drop in excess to assure complete reduction. Cool to 20°C., add 60 ml. of distilled water and then pour in all at once 20 ml. of saturated mercuric chloride solution, with agitation to insure instantaneous mixing. There should be a white, silky precipitate. (If the precipitate is dark in color, it indicates too great an excess of stannous chloride and the entire procedure must be repeated on a new sample. If there is no precipitate, it indicates a deficiency in stannous chloride and the entire procedure must be repeated on a new sample.) Add 30 ml. of 25 per cent phosphoric acid solution and seven to ten drops of diphenylamine barium sulfonate indicator. The volume of the solution should be between 150 and 200 ml.

4C.2.4. *Titration* (following either of the reduction methods). Titrate with standard potassium dichromate solution slowly, with constant stirring. Near the endpoint the green color of the solution deepens to a blue green, or, in the presence of large amounts of iron, to grayish blue, and beyond this point the dichromate solution is added, dropwise, until the color changes to an intense violet blue. 0.05 ml. (indicator correction) should be subtracted from the volume of the dichromate used.

4C.2.5—*Calculation:*

$$\frac{\text{Net ml. } 0.1N\ K_2Cr_2O_7 \times 0.005584}{\text{Weight of sample}} \times 100 = \text{per cent iron (Fe)}$$

NOTE: In the zinc reduction method, it is important for the zinc to be weighed accurately in order that the same amount will be in the blank as in the determination. The dichromate method has considerable advantage over the permanganate method in that there is no fading, back titration with the standard ferrous solution is possible and organic substances do not interfere. Zinc, aluminum, manganese, nickel, cobalt and chromium do not interfere. Copper in quantities above 1 mg. lowers the results. Trivalent arsenic raises the results.

Sec. 5C—Free Acid

5C.1—*Reagents:*

(a) 99 per cent isopropyl alcohol

(b) 0.05*N* sodium hydroxide, carbonate free

(c) Phenolphthalein indicator

5C.2. *Procedure.* Place 12.25 g. of the sample in a 500-ml. glass-stoppered Erlenmeyer flask. Add 100 ml. of isopropyl alcohol and shake with a rotary motion for ten minutes. Filter through a Gooch crucible, retaining as much of the ferrous sulfate in the flask as possible. Wash the residue in the flask with two 25-ml. portions of alcohol. Wash the Gooch crucible with a final 25-ml. portion. Titrate the filtrate with sodium hydroxide using phenolphthalein as the indicator. Run a blank using the same procedure and the same amount of alcohol. Subtract

the reading obtained on the blank from that obtained on the treated sample.

5C.3—*Calculation:*

$$\frac{\text{ml. } 0.05N \text{ NaOH} \times 0.00245}{\text{Weight of sample}} \times 100 = \text{per cent free acid (as } H_2SO_4\text{)}$$

5C.4—*Sodium Hydroxide Correction:*

The amount of NaOH employed in the determination includes the amount used in reacting with the ferric sulfate that is taken in solution by the alcohol. If the percentage of free acid, as calculated, does not exceed the maximum set in the specifications, no correction need be made for the NaOH used by the ferric sulfate. If the percentage of free acid, as calculated, exceeds the amount specified, the quantity of NaOH used in the reaction with the ferric sulfate may be determined as follows:

5C.4.1. After the titration with the NaOH is completed, evaporate the alcohol on a steam bath. Determine the amount of iron in the residue, either colorimetrically or gravimetrically.

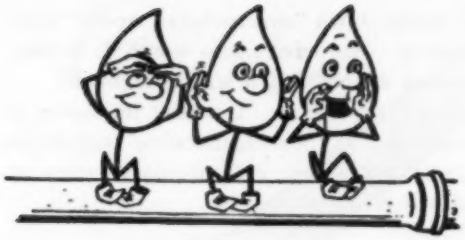
5C.4.2. The quantity of NaOH used in the reaction with the iron as ferric iron is calculated from the equation:

$$\frac{\text{Weight of iron} \times 2.149}{0.002} = \text{ml. } 0.05N \text{ NaOH}$$

5C.4.3. Subtract the quantity of NaOH used by the reaction with ferric sulfate from the actual quantity used in titrating the alcoholic solution. The quantity of NaOH used in titrating the free acid will be the remainder.

NOTE: Ferrous sulfate always contains some ferric sulfate. Ferrous sulfate is insoluble in isopropyl alcohol but ferric sulfate is slightly soluble and is the source of the iron found in the alcoholic extract.

These "Tentative Standard Specifications for Ferrous Sulfate" were prepared under the direction of C. K. Calvert (deceased) and J. E. Kerslake of the Water Purification Division, A.W.W.A. The specifications were approved by the Executive Committee of the Water Purification Division and by the Water Works Practice Committee, and received the approval of the Association's Board of Directors on May 31, 1949. The specifications were also submitted for review to producers and consumers of the materials involved, whose comments were then considered by A. V. Graf, acting as referee. The text as finally edited was approved by the Executive Committee of the Water Purification Division on August 11, 1950.



Percolation and Runoff

Down in Missouri, where folks are known to have to be shown, a psychic phenomenon really has to be phenomenally psychic to get any attention at all. Thus we have no recourse but to believe in the bottomless barrel of Simmons, Mo. Attested not only by farmer J. B. Orr (its owner), his wife (who at first doubted) and a host of strictly inquisitive visitors, but by one W. W. Cox, associate member of the American Society for Psychical Research (who spent 24 hours with the barrel), as a *"genuine* supernatural happening," this latest answer to the water shortage ought to be the last.

Reportorially speaking, farmer Orr last May placed a 50-gal. barrel on a platform in his yard, filled it with water from a river a quarter-mile from the farm, uses the water daily—piping it to his chickenhouse feeding pan—has never added a drop of water since. Although the chickens use about six or seven gallons a day, the barrel is still full and on some days, presumably when the chickens aren't thirsty, overflows. When investigator Cox, a hoaxmaster from way back, made his check, he removed several inches of water from the barrel, stayed right with it, then measured it again and found it had already gained three inches. Mrs. Orr's doubts were dispelled only when her husband was bedridden and, thus, couldn't have continued pulling her leg. Other doubters must have been convinced too, for the *Associated Press* reports no conflicting opinion—only some garbled verbiage concerning the Brannan plan.

At any rate having had our initial qualms quashed by the authoritative voice of the A.S.P.R., we now have no business making you unhappy too, so let's welcome the return of an improved rain barrel as the last answer to all our problems. Over the counter this will probably be sold as the *Oeuvre d'Orr,* which will just mean that it's more caveat than caviar.

Oops! It's Orr d'Oeuvre now. A later *AP* report gives word that one of those "thousands of visitors," who apparently took his Missourism with the old-time seriousness, turned the barrel over to find out

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(Continued from page 1)

what made it trickle. And since upside down "supernatural" spells "larutanrepus," it naturally isn't functioning. But what seems worse, J. B. himself has turned antipsychic, expressing doubt "that it will be righted."

All of this confirms us in our first conviction. It wasn't the barrel at all that was remarkable, but the *water* in it. "Self-regenerative" you might say, or "heavy water on a diet," but anyway quite extraordinary—even for water. New York City could have used a sample.

The facts of Life magazine's recent six-page spread on "U.S. Water" indicated that we as a nation have all the water we need, but that we're going to have to shell out plenty to get at it. What with war and the memory of war all around us though, the cost of water must still appear only a drop in the bucket by comparison. And money invested in water has never yet failed to pay dividends.

The billion and a half dollars already spent by the Bureau of Reclamation, for instance, have already started trickling back and will eventually be repaid with interest by the agriculture and industry which the reclamation projects support. The cost of bringing the Northwest's excess water to the arid Southwest, too, would be as nothing compared with the yield of the area thus restored to productiveness. And a price of $800,000,000 on the Incodel plan for supplying large areas of New York, New Jersey and Pennsylvania with Delaware River water is bound to be cheap in the long run.

Speaking of large projects, though, another in the $300,000,000 to $500,000,000 bracket which is going to pay water supply dividends, though that is only an incidental consideration, is the U.S. Bureau of Mines proposed 300-mile coal fields drain bore. Plans, which will be ready for review in a couple of years, call for a 300-mile long twin-bore tunnel running from the coal fields of central Pennsylvania to tidewater near Havre de Grace, Md. The main purpose of the project is to drain the water that is now sealing off millions of tons of anthracite, thus doubling the remaining life of the Pennsylvania field. And the "incidental" benefit will be a 600,000-gpm. supply of "excellent" water piped through a heavily populated industrial area frequently threatened with water shortages.

To water works men, that's anything but a "bore."

Rene J. La Marre has resigned his post with the Adrian, Mich., Water Dept. to accept a key position in a new water treatment plant which is about to be placed in operation in Guayaquil, Ecuador. The plant was constructed for the city by Pitometer Co.; Buck, Seifert & Jost; and Frederick Snare, Inc.—all of New York. La Marre will function as superintendent of filtration.

(Continued on page 4)

Announcing a

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Ore Mines, Beneficiation Plant, Blast Furnace, Coke Plant
LONE STAR, TEXAS

(Continued from page 2)

Two government reorganization plans of interest to water works men have been proposed by President Truman and, in the absence of Congressional objection, are now in effect. Plan No. 16 transfers from the General Services Administration to the Federal Security Administration all functions implementing the water pollution control act. Plan No. 17 removes from the General Services Administration to the Housing and Home Finance Agency both the Communities Facilities Service and the loan program for the advance planning of nonfederal public works which CFS has been administering all along.

Application of the Fair Labor Standards Act to water utilities, which was mentioned recently in these pages (June P&R, p. 8), has been clarified somewhat by a statement made by the administrator of the Wage and Hour and Public Contracts Divisions of the U.S. Dept. of Labor. Under the terms of the act, "employers" subject to its provisions do not include the federal government or any state or political subdivision of a state. Utilities operated by local governments are therefore exempt from coverage, although the act still applies to privately owned water utilities.

(Continued on page 6)

TENNESSEE CORPORATION
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2. The time required for floc formation, conditioning, and settling is in many cases considerably shorter than that required for other coagulants.
3. Filter runs have been markedly increased in several cases.
4. Manganese is successfully removed at pH values above 9.
5. Effluents may be produced which are exceedingly low in both iron and aluminum.
6. Hydrogen sulfide is removed, and taste and odor improved.
7. Ferric floc does not seem to stick to sand grains to form mud balls, and is subject to less "breaking through" on the filters.

TENNESSEE CORPORATION
Atlanta, Georgia — Lockland, Ohio

COMPLETE..VIOLENT..INSTANT..UNIFORM

American HOMOMIX CHEMICAL MIXING *without a Mixing Tank*

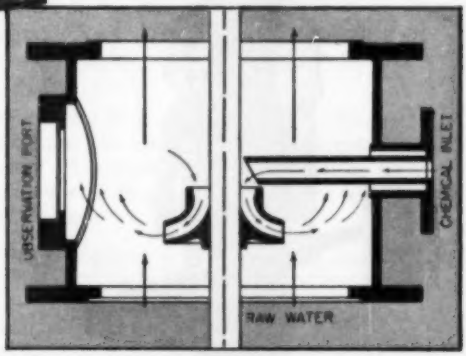
2-stage Homomix

(Patent applied for)

The HOMOMIX gives instantaneous, violent, and uniform mixing of one or more chemicals, or gases, with water. *Immediate, total diffusion*—the most important factor for the efficient and economical addition of chemicals or gases—is obtained *without the use of a mixing tank!* For new plants it eliminates the necessity for costly mixing tank construction; for existing plants it can be effectively used to improve treatment.

The HOMOMIX, in one or more stages, is installed in, and forms part of, the piping. Diffuser impellers rotate in blending chambers and discharge directly across the flowing-through stream. Each chamber has one or more chemical inlet connections and a transparent plastic observation port through which the mixing action is visible. A lifting stage can be provided for additional head, if required.

Write for "Technical Supplement HM" . . . Complete Design Data



Our staff of Sanitary Engineers will cooperate with consulting and operating engineers in suggesting the process of treatment and type of equipment best suited to individual needs.

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RESEARCH · ENGINEERING · MANUFACTURING

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(*Continued from page 4*)

Hill Gresham, business manager of the Southwest Water Works Journal, died on September 13. Together with his brother Bob, who carries on as the publication's editor, he had been an important contributor to the activity and advancement of the water works field in the Southwest.

New York State has reactivated its Mutual Aid for Water Service Plan, with Earl Devendorf, director of the Bureau of Environmental Sanitation of the State Health Dept. and state water coordinator during World War II, again in charge. The cooperative plan provides for the interchange of water between adjacent communities through interconnections, and the transfer of materials and personnel, whenever required by war-induced disaster. Other defense preparations being made by the State Health Dept. include the training of sanitary engineers and sanitarians in the safeguarding of public water supplies, food and milk in the event of an atomic explosion.

The California Municipal Utilities Assn. is holding its annual conference November 7–10 in Long Beach. Headquarters will be at the Lafayette Hotel.

(*Continued on page 8*)

M-SCOPE Pipe Finder

LIGHTWEIGHT MODEL

Catalog No. 25K

On Request

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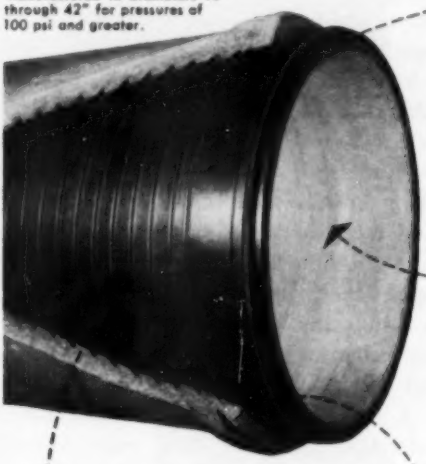
Pipe Line Equipment

New Hyde Park **New York**

THE DEPENDABLE STRENGTH OF AMERICAN CONCRETE CYLINDER PIPE IS A RESULT OF SUPERIOR DESIGN

Steel and concrete components of this outstanding composite design work together to give superior resistance both to internal and external stresses.

Manufactured in diameters 14" through 42" for pressures of 100 psi and greater.



1 Steel cylinder provides a positive water seal or membrane as well as part of the required total steel area*. (Thickness of the cylinder varies according to pipe diameters and general design requirements). Each cylinder is hydrostatically tested to a unit stress of at least 22,000 psi.

2 Centrifugally spun concrete lining is of proper mixture and dense compaction. Its thickness adds rigidity and strength through "arching" effect (nominal minimum lining thickness is ½" for 14" and 16" diameters and ¾" for larger diameters). Cylinder is lined prior to rod wrapping.

3 Steel reinforcing rods, which supplement the required steel area*, are wrapped under measured tension and accurate spacing around the concrete lined cylinder. The section modulus is thus increased while the concrete lining is placed under slight initial compression. The result is, in effect, a modified prestressed design.

4 Dense concrete jacket or coating (nominal minimum 1" thickness over the cylinder) is "locked" around the rod wrapping over the entire surface of the cylinder. This is an important structural feature.

*Total cross sectional steel area is based on 13,500 psi max. allowable unit stress at the design operating pressure.

Superior design affords the most economical and effective use of steel and concrete to produce the best quality of pressure pipe at less cost to the purchaser. Economical first cost plus ease of installation, sustained capacity and trouble free service all help to reduce the cost of delivered water.

Complete information upon request.

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Concrete Pipe for Main Water Supply Lines, Storm and Sanitary Sewers, Subaqueous Pipe Lines

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District Sales Offices and Plants — Oakland • San Diego • Portland, Ore.

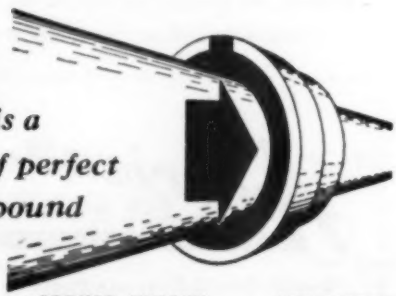
(*Continued from page 6*)

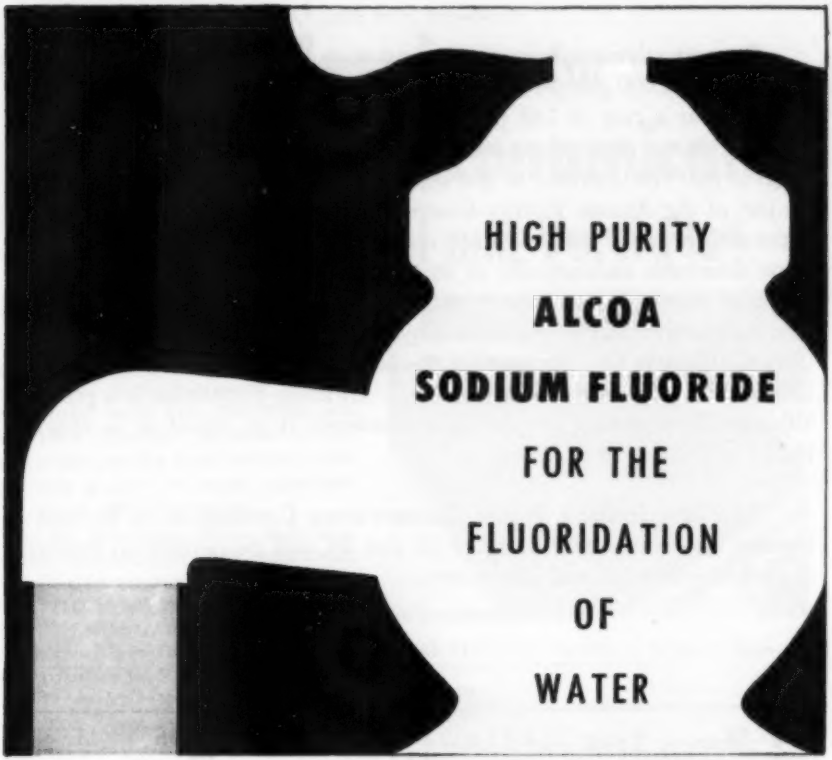
Rainmaking is practically passé. When pioneers in a field begin agitating for licensing and controls, as has Dr. Bernard Vonnegut, one of General Electric's weatherwonderworkers, we can immediately assume overcrowding. Of course, Dr. Vonnegut claims that such action will be made necessary by the "haywire seeding operations" of hosts of amateur rainmakers, which and who, he says, are raising such havoc with clouds and their physics that the "highly qualified investigators" engaged in "scientifically conducted operations" no longer know which rain is theirs, which Nature's and which thunderheadhunting Farmer Brown's. Having observed the uncertainty with which New York City's Dr. Howell has identified any storm under any circumstances, we sort of doubt whether that's the whole story; and being anything but unaware of Dr. Howell's well-publicized $100 per day, we can understand why the amateur professionals are getting the professional amateurs up in the air. Anyway, if the former really "unknowingly seriously impede the progress of meteorological science," maybe we can at least have a sunshiny World Series.

With rainmaking so passé, we've had to look elsewhere for real news of combating water shortage, and where else but in the funny sheets. There it was that Popeye's pal, J. Wellington Wimpy, almost made a million dollars promoting the development of a dehydrated water to which "you merely add water." If he had gotten away with it, we would have gone into production immediately on our own invisible pill to which, also, "you merely add water," but as he failed, we began to wonder what happened to the water taken out of foods that were dehydrated. And therein undoubtedly lies the answer to the water problems of such citrus fruit states as Arizona and California. If all the water taken out of all the oranges and grapefruit now being "concentrated" were available for use, the Colorado controversy would soon be forgotten. Why, first thing you know, orange growers would be publicizing whole fruit again just to prevent a flood.

At any rate, if rainmaking is passé, this is perhaps *assez.*

(*Continued on page 10*)

Every bag of
BOND-O
Homogenized
is a bag of perfect jointing compound

NORTHROP & COMPANY, INC. | SPRING VALLEY NEW YORK



ALCOA Sodium Fluoride, like all other Alcoa Chemicals, has a uniform high degree of purity. It may be used with confidence for the fluoridation of water supplies. ALCOA Sodium Fluoride flows freely . . . is easy to handle . . . dissolves at a uniform rate. Besides that, ALCOA is a *dependable* source of supply.

If your community is fluoridating its water supply—or is considering doing so—let us discuss with you the properties of ALCOA Sodium Fluoride that make it particularly suitable for your use. Write to ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 624 Gulf Bldg., Pittsburgh 19, Pennsylvania.

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(*Continued from page 8*)

Conservation-conscious water works men may be startled to know that about 125,000 gal. per month of water is being distilled to a high degree of purity, at a cost of 14¢ per gallon, and then simply dumped into the Mohawk River at a point about six miles from Schenectady, N.Y. The catch is that the operator of the still is the Knolls Atomic Power Lab., a project of the Atomic Energy Commission, and the water going to waste is the effluent of the unit's radioactive water disposal plant. Although there is no detectable radioactivity in the condensate, it may be presumed that potential users find the water excessively high in psychological hazard. The radioactive slurry left behind by the distillation process is dried by General Electric Co., operator of the laboratory for AEC, and at present is being stored in stainless steel drums. Ultimate disposition is a problem, although a suggestion frequently encountered is to imbed it in concrete blocks and dump them at sea.

The first Indiana Water Conservation Conference, to be held at Purdue University on November 28 and 29, will be devoted to problems of ground water use and conservation.

(*Continued on page 12*)

3 *Money, Time and Labor Saving Features of*

UNIVERSAL*

CAST IRON PIPE

LAID WITH ONLY WRENCHES

NO CAULKING MATERIALS

NO GASKETS. NO BELL HOLES TO DIG.

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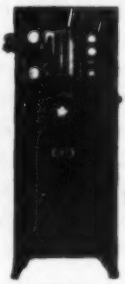

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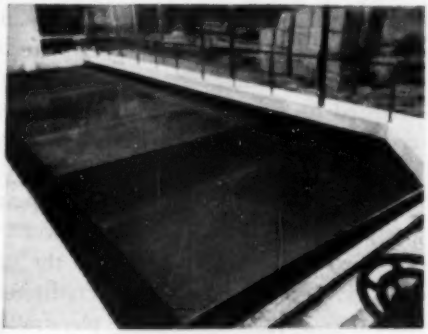
modernize—for greater capacity—economically with Rex Floctrol and Verti-Flo!

When increased demands exceed the capacity of your water treatment plant, you can bring your plant up-to-date . . . step up capacity . . . economically with **REX FLOCTROLS** and **VERTI-FLO** Clarifiers. Installed in new or existing tanks, these efficient units provide greatly increased capacities . . . more effective results.

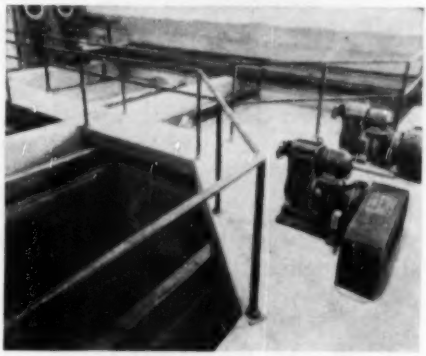
At the Fairmont, Minn., treatment plant, for example, **REX FLOCTROLS**, installed in modernized tanks, and a **VERTI-FLO** in an existing tank, made possible an increase in plant capacity from the originally designed capacity of 500,000 G.P.D. to 2,000,000 G.P.D. *without increasing the physical size of the plant.*

Tests show that the chemical reaction is complete within the **FLOCTROL** despite the extreme seasonal changes in water temperature.

The **VERTI-FLO** equipment was installed in two existing rectangular settling tanks, providing for and efficiently handling 2,000,000 gallons daily, an increase of 1,500,000 gallons daily over the original designed capacity of the two conventional tanks. Detention time was reduced from 6.2 hours to 1½ hours, and solid removals were remarkably improved. Effluents were improved to the point where filter runs were increased 5 to 6 times.



REX VERTI-FLO Clarifier at Fairmont, Minn.



REX FLOCTROLS at Fairmont, Minn.

Why not reap the benefits of this modernization for your plant? For complete details and informative literature, write: **CHAIN BELT COMPANY, 1609 W. Bruce Street, Milwaukee 4, Wisconsin.**

CHAIN BELT REX COMPANY

WATER TREATMENT EQUIPMENT

(*Continued from page 10*)

Bruce Barton lives in a benighted area. And one of the big reasons why Bruce Barton calls his area—the New York of a New York *Journal-American* columnist—"benighted" is the fact that "our water supply was so low last winter that on certain days we were forbidden to shave or to take a bath." About such other signs of "benightedness" as old schools, traffic congestion, slums and inadequate hospitals, we aren't privileged to comment; nor should we discuss here the Barton plan for curing all these ills by spending "President Truman's Point Four" money on a charity-begins-at-home drive in New York City. What we must be a little indignant about is the factual incorrectness of his "forbidden" statement concerning the conservation drive, much of the success of which has been credited to the very fact that, as far as the domestic consumer was concerned, it was entirely voluntary. As a matter of fact, reading Mr. Barton's column, in which he also points out that other areas throughout the U.S. are also benighted because of inadequate water supplies, it occurs to us that perhaps Mr. Barton's use of the word "benighted," as well as that of "forbidden," varies materially from the usually accepted one. Either that or he's giving water even more credit than we do for its powers—indicating that they extend beyond the physical to the moral necessities.

About the only unbenighted thing in Mr. Barton's entire essay is President Truman, who is credited with "a private plane and luxurious yacht"—the moral, undoubtedly: make sure your son grows up to be president; never, never a water works man.

Harvey F. Ludwig, consultant and associate professor of sanitary engineering at the University of California, has been retained by the U.S. Public Health Service as consultant to the Office of Health Emergency Planning at Washington, D.C. He is working with sanitary engineer director Gordon E. McCallum on sanitary engineering aspects of civilian disaster relief.

(*Continued on page 14*)

SUBMERGED PIPE LINE CONSTRUCTION

BOYCE COMPANY

Phone 3-2530 **Clearwater, Fla.**

Easy to lay MECHANICAL JOINT

M & H VALVE
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ANNISTON, ALABAMA

Our Mechanical Joint Valves, made to AWWA specifications, are furnished in sizes 2″ to 30″, and valves approved by Underwriters and Associated Factory Mutuals are furnished in sizes up to 12″. Iron body, bronze mounted, double disc, parallel seat, hydrostatically tested at 350 lbs. for water working pressures of 175 or 200 pounds. Post Indicator Valves with Mechanical Joint feature are available for use with indicator posts when valves are installed on underground pipe line to serve sprinkler system requiring Underwriters and Associated Factory Mutual's acceptance.

Mechanical Joint features are: Ease and speed of installation, construction economy, joint deflection, leak-tight, long life. Used with AWWA Class A, B, C, D; Federal Spec. WW-P-421; or Class 100, 150, 200, 250 centrifugal pipe.

Fig. No. 67M

WRITE FOR CIRCULAR NO. 49

Our New Circular No. 49 shows important installation dimensions of M & H AWWA Mechanical Joint Hydrants and Valves . . . . Underwriters and Associated Factory Mutual approved Post Indicator Valves . . . . and Cutting-In Sleeves.

M & H Products · Everywhere

(*Continued from page 12*)

Always thinking of our stomach, we had a bad time at our desk the other day when the announcement of future "Meetings of Certain A.S.T.M. Technical Committees" reached us there. Knowing the catholicity of A.S.T.M.'s standards activities, we are always ready for some encyclopedic exercise in its programs. Thus we almost whipped right on by Committee C-19, and would have but for a certain succulent sensation in our salivary glands. Doubling back, we noted the dates, October 26 and 27, the place, Madison, Wis., and put in a call for train reservations before we got hold of our instincts and imagination long enough to give second thought to the probable activities of a "Committee on Structural Sandwich Construction." All that would enter our consciousness were disconnected deliria having to do with Dr. Dagwood Bumstead, the ham and cheese concept, the bologna curve on the square loaf, and the skyscraper vs. the tenement theory of club construction. Unable to think above the rumble of our digestive dithers, we put in an emergency call to one of our friends over at A.S.T.M. *He* was "out to LUNCH!" What finally brought us around was the information that Committee C-19 was developing strength specifications for laminated plywood. They should ask us about stress.

(*Continued on page 16*)

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Accurate American Meters
The superior accuracy built into Buffalo AMERICAN Meters enables you to earn full revenue from metered water in your system. Metered water is "fair to all." Write for details.
BUFFALO METER COMPANY
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water problems got you down?

LET Ozone HELP!

If you're tired of fighting an uphill battle against taste, color or odor, you should investigate the Welsbach Ozone process.

For example in Philadelphia, long accustomed to drinking notoriously unpalatable water, many residents are now enjoying water of mountain-stream freshness . . . thanks to Ozone. The operation of the country's largest Ozone water treatment plant at the Belmont Filtration Works brings to vast numbers of Philadelphians the best drink in the world. You, too, can give your community the best drink in the world—water that looks right, smells right and tastes right—with the Welsbach Ozone process.

Don't let problems created by old-fashioned water-treatment methods get you down. Write to The Welsbach Corporation, Ozone Processes Division, today. Without obligation on your part, our engineers will offer helpful recommendations on how Welsbach-Ozone can help you overcome your difficulties.

THE WELSBACH CORPORATION

OZONE PROCESSES DIVISION

1500 Walnut Street Philadelphia 2, Pa.

(Continued from page 14)

One hundred years of chemical manufacturing activity was celebrated by the Pennsylvania Salt Mfg. Co. during the week of September 25 with a program of centennial observances commemorating the company's history. Founded by a group of young Philadelphia Quakers who invested their savings in a new—and, as it turned out, unsuccessful—process for making alkalies from salt, the company struggled through five years of failure and hardship to establish itself as one of the country's leading basic chemical manufacturers, with current production valued at $38,000,000 annually.

Sewage treatment by three major processes is the subject of four film strips just prepared by the Communicable Disease Center of the U.S. Public Health Service. Intended for showing to sanitarians and sanitary engineers responsible for plant supervision, as well as professional trainees in engineering and public health schools, the strips are available for showing to qualified groups without charge. Loans may be arranged through the Utilization Section of the Audio Visual Production Services, Communicable Disease Center, U.S. Public Health Service, 605 Volunteer Bldg., Atlanta 3, Ga.

Karl R. Kennison is retiring as chief engineer of the Metropolitan (Boston area) District Commission's Construction Div. The Quabbin water supply project and Hultman Aqueduct on which he had worked have both been completed. He anticipates doing some consulting work in hydraulic engineering.

A portable electric saw with an 8½-in. blade capable of making a 2⅛-in. cut is being offered by Syntron Co., 949 Lexington Ave., Homer City, Pa. The saw is driven through dual V-belts by a 1½-hp. motor, thus cushioning the motor against sudden shocks or overload. The saw is adjustable to vary depth or bevel of cut.

(Continued on page 18)

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Cathodic PROTECTION
not just . . .
Cathodic Protection Equipment
call . . .
ELECTRO RUST-PROOFING

NO two corrosion problems are exactly alike — that's one reason stereotyped solutions won't work. Cathodic protection, properly engineered and applied, is economical, effective and practical. E.R.P. offers preliminary engineering, design, equipment and installation services for an individual solution to each particular problem. For data on cathodic protection of structures from pipe lines to elevated tanks, call on E.R.P. without obligation.

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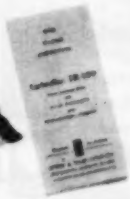
50% LESS SALT

REGENERATES THIS WATER-SOFTENING RESIN!

• Here is a real water-softening economy. AMBERLITE IR-120 cuts salt consumption virtually in half! One quarter of a pound of salt per 1000 grains of hardness removed restores this synthetic ion exchange resin to high adsorptive capacity. Yet the resin is undamaged by this salt starvation, and the quality of softened water is not decreased.

Besides high regeneration efficiency, AMBERLITE IR-120 offers long, trouble-free service—even when exposed to waters that dissolve siliceous exchangers and reduce their capacity. A typical AMBERLITE installation has already set a through-put record of 2,500,000 gallons of water per cubic foot of exchanger, and is still going strong.

Next time you talk with your consulting engineer, or to a manufacturer of water-treating equipment, ask him about AMBERLITE IR-120—as a replacement for siliceous exchangers, or as the exchanger in a new softening installation. Meanwhile, write Dept. WWI-10 for your copy of our pamphlet on AMBERLITE IR-120.



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CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square Philadelphia 5, Pa.

The Resinous Products Division was formerly The Resinous Products & Chemical Company

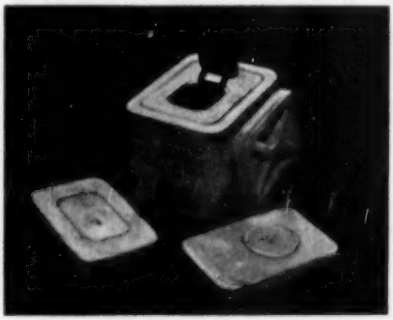
(Continued from page 16)

Women drivers are always getting it in the neck; women parkers even more so. Thus, Mrs. John Urgo of Hempstead, N.Y., must have had a wonderful "I told you so" the other day, when her husband checked and verified the fact that the hydrant nozzle which scraped her fender while she was parking the family car actually did protrude beyond the curb. The two inches that it protruded may have been cutting the reason a little fine, but fact is fact, which even the Town Board recognized in coughing up $25 in damages and ordering the hydrant moved back a foot and a half. Why she was parking in a hydrant zone anyway wasn't mentioned, so take heed, the season may be open.

Robert H. Steiner has been appointed research coordinator of Atlas Mineral Products Co.

Jack E. Cooper, formerly supervisor of the Ford Motor Co. Water & Wastes Lab., has joined F. W. DuBois, whose recently organized sales engineering firm of Detroit will now be known as DuBois-Cooper Associates. Cooper is currently chairman of the Michigan Section, A.W.W.A.

(Continued on page 22)



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Since 1911 more than 1,500 different water systems throughout the Pacific Coast and Southern states have installed Art Concrete Meter Boxes!

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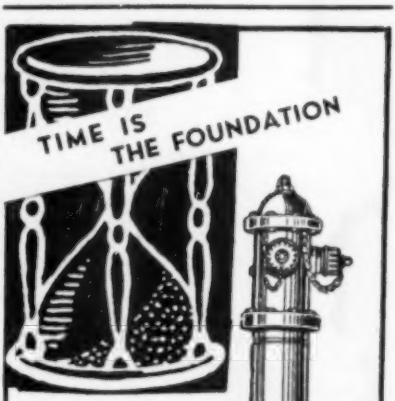
SOUTH HOUSTON, TEX. SHREVEPORT, LA.
SAN DIEGO, CALIF. PHOENIX, ARIZ.



Time is the foundation of Kupferle Fire Hydrant leadership . . . dependability proven by a half century of service.

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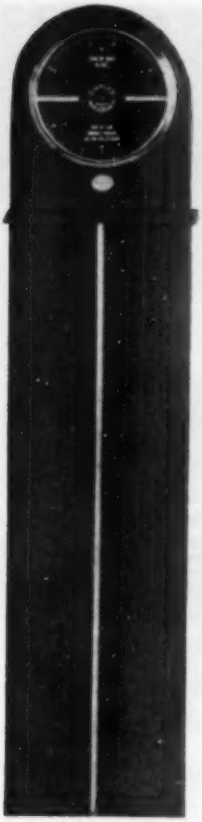


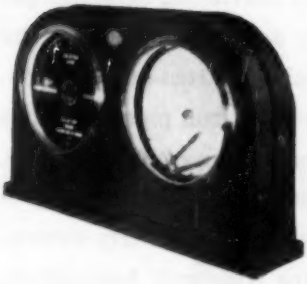
These newly designed FILTER GAUGES

ARE STREAMLINED STURDIER, SIMPLIFIED

Simplex takes pleasure in introducing a brand new line of filter gauges . . . streamlined, sturdier, simplified, and even more accurate than before. These gauges have been especially designed for easy installation and long life with a minimum of maintenance.

Whether you wish to measure flow rate through a filter or from a wash water tank . . . or the loss of head across a filter . . . or to determine clear well or settling basin depths . . . or to visualize filter bed expansion—one of the available types will exactly suit your needs. These rugged, accurate gauges are useful too for the summation of flows at different locations.

Every consulting engineer should have our new free Bulletin 1000 in his file. It describes fully these new gauges and shows installations, types of mountings, dimensions, cross section cuts, etc. Just write to Simplex Valve & Meter Co., Dept. 10, 6784 Upland Street, Philadelphia 42, Pa.



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SIMPLEX

VALVE AND METER COMPANY

Without shock strength—or, for that matter—without all of the strength factors listed opposite—no pipe laid 100 years ago in *city streets* would be in service today.

But, in spite of the evolution of traffic from horse-drawn vehicles to heavy trucks and buses—and today's vast complexity of subway and underground utility services—cast iron gas and water mains, laid over a century ago, are serving in the streets of more than 30 cities in the United States and Canada.

Such service records prove that cast iron pipe combines all the strength factors of long life with ample margins of safety.

No pipe that is provably deficient in any of these strength factors should ever be laid in city streets.

Cast Iron Pipe Research Association,
Thos. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3.

CAST IRON PIPE

Strength factors of Long Life !

No pipe that is provably deficient in any of these strength factors should ever be laid in city streets

SHOCK STRENGTH

The toughness of cast iron pipe which enables it to withstand impact and traffic shocks, as well as the hazards in handling, is demonstrated by the Impact Test. While under hydrostatic pressure and the heavy blows from a 50 pound hammer, standard 6-inch cast iron pipe does not crack until the hammer is dropped 6 times *on the same spot* from progressively increased heights of 6 inches.

CRUSHING STRENGTH

The ability of cast iron pipe to withstand external loads imposed by heavy fill and unusual traffic loads is proved by the Ring Compression Test. Standard 6-inch cast iron pipe withstands a crushing weight of more than 14,000 lbs. per foot.

BEAM STRENGTH

When cast iron pipe is subjected to beam stress caused by soil settlement, or disturbance of soil by other utilities, or resting on an obstruction, tests prove that standard 6-inch cast iron pipe in 10-foot span sustains a load of 15,000 lbs.

BURSTING STRENGTH

In full length bursting tests standard 6-inch cast iron pipe withstands more than 2500 lbs. per square inch internal hydrostatic pressure, which proves ample ability to resist water-hammer or unusual working pressures.

SERVES FOR CENTURIES

(*Continued from page 18*)

Shades of the Ancient Mariner rode the waves with the new French "luxury liner," *Liberté*, on her maiden voyage from Le Havre to New York last month. Without ever sighting an albatross, the 1,246 passengers felt they knew whereof the old gent with "the long grey beard and glittering eye" spoke, when the ship's fresh water tanks sprang a leak and spilled more than 100,000 gal. into the hold before repairs could be made. Even with distillation equipment desalting a reported 600 tons per day, the order of the cruise was "no hot water for bathing or shaving"—and for anyone much over ten years of age, that ain't luxury. Of course, although supplies of drinking water were still more than adequate, many superconscientious passengers insisted on cooperating even to the extent of donating their share of that to the more needy, slaking their own martyric thirsts as best they could on the 6,500 bottles of champagne which flowed over the vessel's seven bars. Particularly those male martyrs whose wives usually supervise their consumption never had it so good.

Really much more the Ancient Mariner, though strictly on the beach, is the caretaker of Wigwam Reservoir of the Waterbury, Conn., water system. Living on reservoir property, with good fresh "water, water everywhere," he just had to dig himself an artesian well at the cost of $1,022. Of course, the city paid, but Supt. Julius Nido can consider himself lucky he got a chance to explain that this was less money than it would have cost to lay pipe and install the necessary pumping equipment. In some places, reporters "shoot first, etc."

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A lightweight pneumatic utility drill for plant maintenance has been developed by Gardner-Denver Co. of Quincy, Ill. Known as model S17, the drill is a self-rotating hammer type for drilling concrete, brick or stone with standard drill steel. An adapter converts the unit to the use of standard star drills. Rotation may be stopped to furnish chipping hammer or pick operation.

(*Continued on page 76*)

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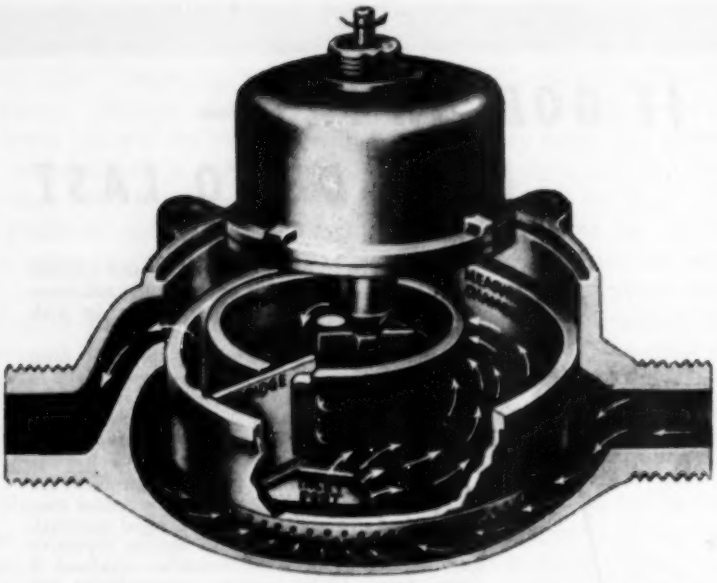

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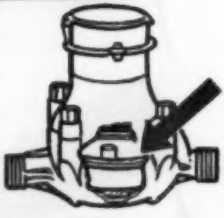

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Allen, Herrick D., Village Clerk, Board of Public Affairs, Swanton, Ohio (July '50)

Allen, James D., *see* Yeatts & Allen

American Lumber & Treating Co., Kenneth E. Nelson, Sales Repr., 1118 Wilshire Blvd., Los Angeles 17, Calif. (Assoc. M. July '50)

Armstrong, Paul H., Supt., Water & Sewage, Post Eng. Div., Milan Arsenal, Milan, Tenn. (July '50)

Aumend, Glann *see* Sylvania (Ohio) Board of Trustees of Public Affairs

Baird, K. B., Mgr., Hydro & Waterworks System, Caledonia, Ont. (Oct. '50)

Baker, Thomas E., Executive Officer, City Board of Health, Dover, Del. (July '50)

Clark, Wayne, Civil Engr., Waste Disposal Eng., Dept. of Los Angeles County Engr., 108 W. 2nd St., Los Angeles 12, Calif. (Oct. '50)

Cla-Val Co., H. B. Pearce, 1600 Orange St., Alhambra, Calif. (Assoc. M. July '50)

Columbus Municipal Water Utility, Robert L. Stevenson, Mayor, Columbus, Ind. (Corp. M. July '50)

Conley, Francis R., Director of Research, Ryder-Scott Co., 1007 Baylor Ave., Wichita Falls, Tex. (Jul. '50)

Cowan, J. C. *see* Alamo Iron Works

Cox, Sherman J., Economist, Bureau of Reclamation, Water Resources Development, Box 825 Huron, S. D. (July '50)

Crandall, Lawrence E., Asst. Director of Public Works & Asst. City Engr., Dept. of Public Works, 2 City Hall, Battle Creek, Mich. (July '50) *M*

Decker, Guy P., Salesman, Johns-Manville Corp., 1220 Madison Ave., Toledo 2, Ohio (July '50)

Denton, Joseph R., Regional Repr., Water Treating Div., Worthington Pump & Machinery Corp., 2 Park Ave., New York, N.Y. (July '50)

Detroit Lakes Water & Light Dept., Clarence H. Nelson, Supt. of Utilities, 106 East Holmes St., Detroit Lakes, Minn. (Mun. Sv. Sub. July '50) *MP*

DeVoe, Sherman W., Sales Engr., Colorado Pump & Supply Co., 160 S. Canosa Court, Denver 9, Colo. (July '50)

Dismukes, M. E., *see* Magnolia (Ark.) Municipal Water System

Donoho, Thomas B., Civil Engr., F. T. Drought, Cons. Engr., 117 W. Pecan St., San Antonio, Tex. (July '50)

Dratwa, Edwin I., *see* Hinckley & Schmitt

Ellison, Robert J., Cons. Engr., 238½ S. Snelling Ave., St. Paul 5, Minn. (July '50)

Enzweiler, Robert, *see* Park Forest (Ill.) Water Co.

Fields Point Mfg. Corp., Daniel Townend, Pres., Box 95, Edgewood Station, Providence 5, R.I. (Assoc. M. July '50)

Goldman, Morton I., Jr. Asst. San Engr., Environmental Health Center, U.S. Public Health Service, 1014 Broadway, Cincinnati 2, Ohio (July '50)

Gustafson, J. P., Mgr., Richmond Business Office, East Bay Munic. Util. Dist., Box 1006, Richmond, Calif. (July '50)

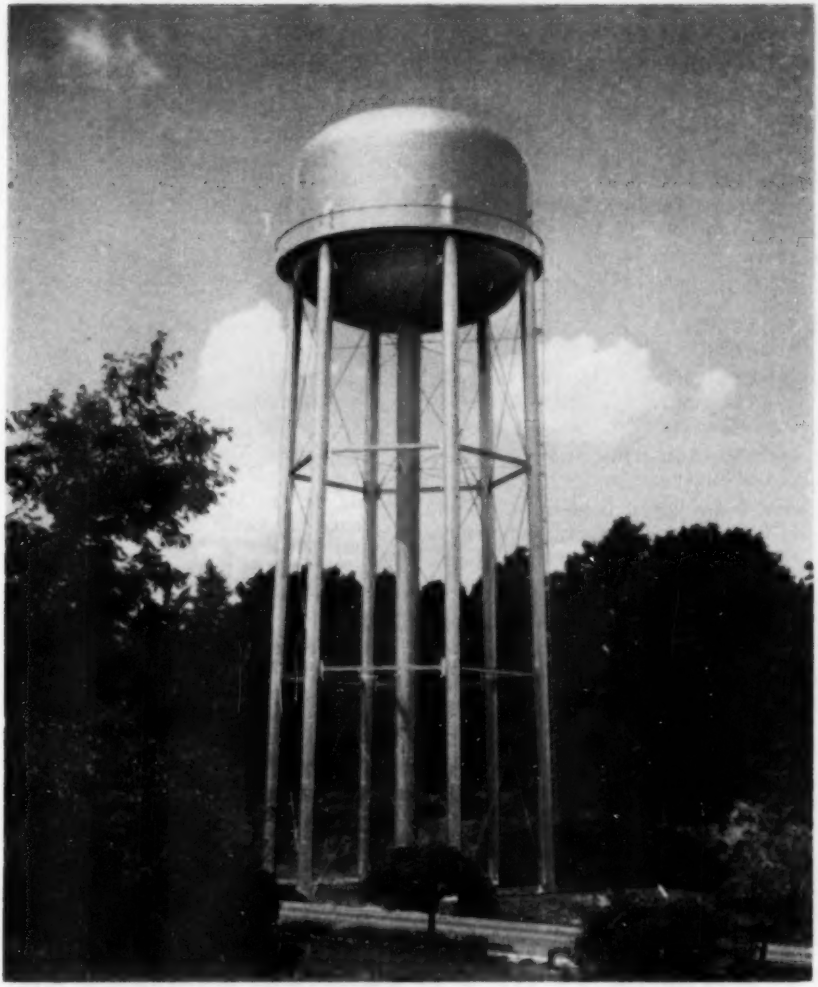
Harvey, J. Mylan, Sales Engr., Chas. H. Tate Co., 992 Union Commerce Bldg., Cleveland, Ohio (July '50)

Haskell, Broderick Phelps, Jr., 912 Gill Court, Albany 6, Calif. (July '50) *P*

Hinckley & Schmitt, Edwin I. Dratwa, Bacteriologist, 420 W. Ontario St., Chicago, Ill. (Corp. M. July '50) *MPR*

Hulsebosch, A. J., *see* International Salt Co., Inc.

(*Continued on page 32*)



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(Continued from page 30)

International Salt Co., Inc., A. J. Hulsebosch, Field Engr., 48 Walnut Ave., Millburn, N. J. (July '50)

Jacobson, Robert Stanley, Jr. Engr., State Dept. of Health, Route 5, Box 206, Charleston, W.Va. (Affil. July '50)

Jordan, Harry S., San. Engr., Bureau of San., State Dept. of Health, Phoenix, Ariz. (July '50)

Klenner, Herman A., Engr., Board of Water Comrs., 1470 Campbell St., Rahway, N.J. (July '50) *M*

Lahart, Walter E., *see* Lenox Water Dept., Town of

Larkins, T. H., Sales Engr., Rockwell Mfg. Co., 8 E. Long St., Columbus, Ohio (July '50)

Leishman, George W., Supt. of Water, Salineville, Ohio (July '50)

Lenox Water Dept., Town of, Walter E. Lahart, Water Comr. & Water Supt., Walker St., Lenox, Mass. (Corp. M. July '50)

Looker, Norman, Estimating Engr., H. W. Alward, Inc., 161 Mt. Airy Rd., Bernardsville, N.J. (July '50) *MPR*

Lubratovich, M. D., Gen. Mgr., Water, Gas & Sewage Disposal Dept., Duluth, Minn. (May '50)

Magnolia Municipal Water System, M. E. Dismukes, Office Mgr., 210 W. Union St., Magnolia, Ark. (Corp. M. July '50)

Magnus, Francis J., City Engr., City Hall, New Ulm, Minn. (July '50)

Martin, Richard E., Gen. Supt., Utility Plant Board, Morehead, Ky. (Oct. '50)

McCrady, John, Jr., Mgr., The John McCrady Co., Box 912, Charleston, S.C. (July '50)

McIntyre, Gene, *see* Victaulic, Inc.

McNaughton, James D., City Mgr.-Assessor, Alma, Mich. (July '50)

Myers, Harry E., Prin. Asst., J. B. Converse & Co., Box 1084, Mobile, Ala. (July '50)

Myers, William Z., Salesman, Power Equipment Co., 223 E. Water St., Oak Harbor, Ohio (July '50)

Nelson, Clarence H., *see* Detroit Lakes (Minn.) Water & Light Dept.

Nelson, Kenneth E., *see* American Lumber & Treating Co.

Norris, Max L., Supt., Board of Public Works, South Haven, Mich. (Jan. '50)

Ohtani, Ralph, Chief Accountant, Board of Water Supply, 1568-C Piikoi St., Honolulu 14, Hawaii (July '50)

Otero Munoz, Rafael, Civ. & San. Engr., Empresas Publicas de Cartagena, Ave. San Martin, Boca Grande, Colombia (July '50)

Park Forest Water Co., Robert Enzweiler, Supt. of Utilities, 2 Plaza, Park Forest, Ill. (July '50)

Pearce, H. B., *see* Cla-Val Co.

Perry, Robert E., Sales & Service Engr., Wallace & Tiernan Co., Inc., 24 Villa Court, Montgomery, Ala. (July '50)

Reed, Carl M., Administrative Officer, 100 Valley Blvd., Escondido, Calif. (July '50) *MR*

Romig, C. O., Mgr., Twin City Water Dept., 316 Grant St., Dennison, Ohio (July '50)

Simpson, Roy L., Operator, Waterworks, 187 Granville Rd. E., Granville, Ohio (July '50)

Smith, E. Clinton, Asst. Mgr., Birmingham Water Works Co., 2114—1st Ave. N., Birmingham, Ala. (July '50)

Staunton, Jack L., San. Engr., Seelye Stevenson & Value, 101 Park Ave., New York, N.Y. (July '50)

Stein, George J., Steinway Eng. Co., 11 Central Pkwy., Mt. Vernon, N.Y. (July '50)

Stevenson, Robert L., *see* Columbus (Ind.) Municipal Water Utility

Stewart, Claude W., Pres., Water Works & Industrial Supply Co., Box 1985, Huntington, W. Va. (July '50)

Sylvania Board of Trustees of Public Affairs, Glann Aumend, Supt., 5630 Main St., Sylvania, Ohio (Mun. Sv. Sub. July '50)

Thompson, William J., Supt. of Filter Plants, Bureau of Water, 8133 Ridge Ave., Philadelphia 28, Pa. (July '50)

Tonry, George, Sales Engr., Barada & Page, Inc., Box 4117, New Orleans, La. (July '50)

Townend, Daniel, *see* Fields Point Mfg. Corp.

Victaulic, Inc., Gene McIntyre, Gen. Mgr., 727 W. 7th St., Los Angeles 17, Calif. (Assoc. M. July '50)

(Continued on page 34)

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(Continued from page 32)

Walton, Jay S., Electrical Foreman, Water Dept., Service Plant, Wardlow & Walnut, Long Beach 7, Calif. (July '50)

Weaver, O'Neal, Supt., Ripley Power & Light Co., Ripley, Tenn. (July '50)

Wendling, Bernhart, Water Supt., Box 344, Blythe, Calif. (July '50)

Winsett, D. L., Asst. Supt. Petroleum Refinery, c/o The Ohio Oil Co., Robinson, Ill. (July '50) *PR*

Wirtz, George L., Jr., Sales Dept., Atlas Mineral Products Co., Mertztown, Pa. (July '50)

Witt, W. O., Water Works Supt., Hughes Springs, Tex. (July '50)

Yeatts & Allen, James D. Allen, 202 Morris Bldg., Abilene, Tex. (Corp. M. July '50) *PR*

REINSTATEMENTS

Parkhurst, E. Raymond, 1811 Canada Blvd., Glendale, Calif. (Oct. '44)

Smallwood, Charles, Jr., Asst. Prof. of San. Eng., North Carolina State College, Raleigh, N.C. (Jr. M. Jan. '46)

Trelles, Ernesto E., Chief Chemist & Bacteriologist, City Water Works, Loma No. 9, Marianao, Havana Province, Cuba (July '38)

LOSSES

Deaths

Colvin, Herbert A., Mgr., South Bay Consolidated Water Co., 89 E. Main St., Bay Shore, N.Y. (Oct. '45) *M*

Lowe, James Carl, Field & Sales Engr., Pulp & Paper Process, Oliver United Filters, Inc., 221 N. LaSalle St., Chicago 1, Ill. (Oct. '43) *MP*

Rice, John M., Cons. Engr., 950 Century Bldg., Pittsburgh 22, Pa. (June '21) *MPR*

Resignations

Bonsal, W. R., Co., Inc., William Roscoe Bonsal Jr., Pres., Hamlet, N.C. (Assoc. M. Jan. '48)

Gasser, Clemont E., Supt., City of St. Petersburg, 322—47th St., N., St. Petersburg, Fla. (Jan. '44) *M*

Norton, P. J., Clerk, Caledonia, Ont. (Apr. '48)

CHANGES IN ADDRESS

Changes received between August 5 and September 4, 1950

Asheville, City of, Thad C. Burnett, Supt. of Watersheds, Box 7148, Asheville, N.C. (Corp. M. Jan. '43)

Bentley, Ralph E., Secy.-Treas., Passaic Valley Water Com., Box 203, Clifton, N.J. (Apr. '43)

Berk, William Leo, 5822 S. Albany Ave., Chicago 29, Ill. (Jr. M. Aug. '50)

Bonyun, Richard E., Gen. Supt., Passaic Valley Water Com., Box 203, Clifton, N.J. (Oct. '35)

Deighton, John T., Passaic Valley Water Com., Box 203, Clifton, N.J. (Oct. '43) *M*

Gordon, Fred F., Cons. Engr., Apartment 10, 2555 Dewey Ave., Rochester 16, N.Y. (July '35)

Grobart, Samuel, Comr., Passaic Valley Water Com., Box 203, Clifton, N.J. (Jan. '50)

Hamilton, Robert L., 784—2nd Ave., S.E., Decatur, Ga. (July '47)

Holton, City of, James W. Bibb, Jr., City Mgr., City Hall, Holton, Kan. (Apr. '49)

Horn, A. John, Denton Hills, Huntington, N.Y. (July '39)

Jacoby, Gordon C., Jacoby, McGrayne & Co., Cons. Engrs., 8 Essex St., Hackensack, N.J. (Oct. '46)

Krell, A. J., 2303 Wroxton, Houston 5, Tex. (Apr. '39)

Lloyd, J. M., 1620 S. Sneed, Tyler, Tex. (Oct. '39)

McCurdy Sand & Water Separator Co., Howard McCurdy, 4875 Pacific Blvd., Vernon 58, Calif. (Assoc. M. Apr. '47)

McCurdy, Howard, Cons. Engr., 4875 Pacific Blvd., Vernon 58, Calif. (Dec. '25)

Ogden, John B., Asst. Gen. Supt., Passaic Valley Water Com., Box 203, Clifton, N.J. (July '38)

O'Neil, William J., Civil Engr., 3329 W. 24th Ave., Vancouver, B.C. (Nov. '49)

Panula, Gustaf Henry, 6151 Greenwood Ave., Chicago, Ill. (Apr. '46)

Perry, A. H., Supervisory Engr., Dept. of National Health & Welfare, Public Health Eng. Div., 425 Howe St., Vancouver, B.C. (Mar. '31)

(Continued on page 36)

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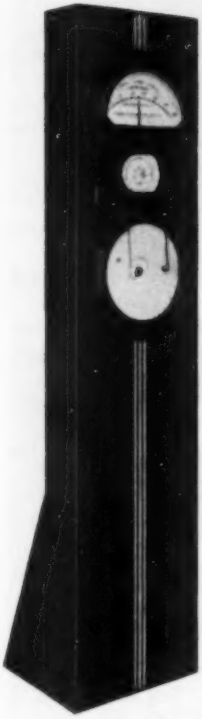

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(Continued from page 34)

Pontusco Corp., H. Lloyd Nelson, Box 425, Baldwin Park, Calif. (Aug. '49)

Riddle, Roland, San. Inspector, Dept. of Water & Power, Box 3669, Terminal Annex, Los Angeles 54, Calif. (Dec. '48)

Schneider, Ernst E., 62 Mequow St., Cedarburg, Wis. (June '49)

Schuhmacher, G. S., Dist. Mgr., Calgon, Inc., 3931 Tweedy Blvd., South Gate, Calif. (Oct. '42)

Secker, William M., Jr., Asst. Engr., Passaic Valley Water Com., Box 203, Clifton, N.J. (Apr. '43)

Spaulding, Charles H., 801 W. Delaware, Urbana, Ill. (July '24) *Goodell Prize* '33. *Fuller Award* '40

Spitz, Benjamin J., Passaic Valley Water Com., Box 203, Clifton, N.J. (Oct. '43)

Stearns, Donald E., 2400 Euclid Ave., Syracuse 3, N.Y. (July '45)

Steenson, Harry E., City Mgr., Lufkin, Tex. (Oct. '39)

Stone, J. W. L., R. R. 2, Excelsior, Minn. (Mar. '49)

Sullivan, David N., Sales Repr., Electro Rust-Proofing Co., 3035 Crestview Ave., Decatur, Ga. (July '48)

Vincent, G. P., Director, Product Development, Mathieson Chemical Corp., 10 Light St., Baltimore 3, Md. (Jan. '45)

Ward, Sylvester E., 2238 Greenside Pl., Scotch Plains, N.J. (Jan. '43)

Water Tank Service Co., L. V. Orr, Pres., 1030 M & W Tower Bldg., Dallas, Tex. (Assoc. M. Jan. '47)

Williams, Walter E., 305 Sterling Pl., Brooklyn, N.Y. (Jr. M. June '50)

Yarabeck, Robert R., Box 55, Station C, Cincinnati 26, Ohio (Oct. '47)

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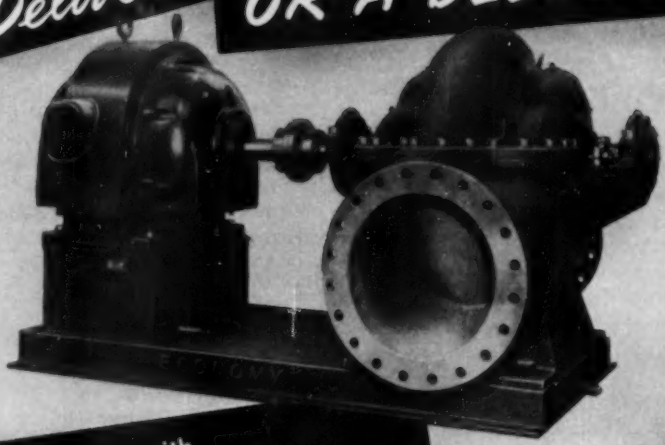

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C.A.—Chemical Abstracts; Corr.—Corrosion; I.M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; S.I.W.—Sewage and Industrial Wastes; W.P.R.—Water Pollution Research (Great Britain).*

CHEMICAL ANALYSIS

Rapid Test for Calcium Hardness. V. M. Marcy. Power, **94**:6:92 ('50). Test described similar to recently developed total hardness test with disodium ethylenediaminetetraacetate dihydrate. Indicator used is stabilized NH_4 purpurate in distd. water. Reagents needed, procedure, calcns. and degrees of interference included.—*C.A.*

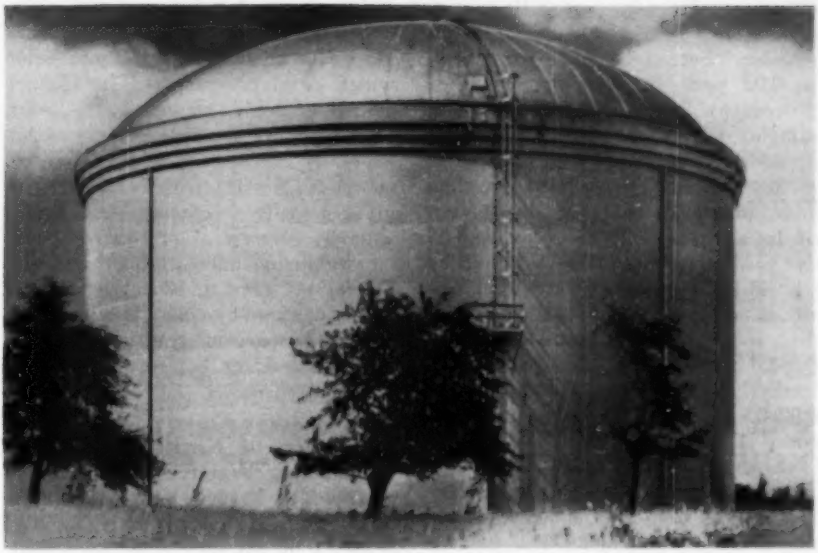
The Calculation of the Concentrations of Free Carbon Dioxide and of Bicarbonate, Carbonate, and Hydroxyl Ions in Natural and Industrial Waters. Vladimir Fähnrich. Chem. Obzor (Czech), **25**:33, 49, 65 ('50). By using mass action law, equations have been deduced for calcn. of concns. of free CO_2 and of its ionic forms, first from pH and total alky., then from pH and total content of CO_2. For theoretical calcns., possible, in waters treated by pptn. methods, to use help of total and apparent alky. (on phenolphthalein) instead of pH. If interionic attraction neglected, error considerably lower. If necessary to respect influence of mineral salts, simply apply first approx. equations of Debye-Hückel's theory, which has been found correct on basis of many expts. Resulting relations have been made into nomographs.—*C.A.*

Determination of Chloride in Water. Frank E. Clarke. Anal. Chem., **22**: 553 ('50). Method of Dubsky and Trtilek improved and adapted to colorimetric and titrimetric procedures for detn. of chloride content of H_2O. In both of these procedures, dil. $Hg(NO_3)_2$ soln. added to acidified H_2O in presence of diphenylcarbazone as indicator. Blue-violet Hg-diphenylcarbazone complex forms, which is proportional in intensity to excess Hg^{++} present. Colorimetric method applicable only to clear waters free of heavy metals, has accuracy of ± 0.5 ppm. Titrimetric method less sensitive to interfering substances than colorimetric procedure and up to 200 ppm. Cl has same accuracy as latter method. These tests require only standard lab. equipment and can be carried out by personnel with very limited experience. Details for construction of app. and for prepg. reagents included.—*C.A.*

The Determination of Free Chlorine in Drinking Water and Bath Water. Georg Gad & Hilde Schlichting. Gesundh.-Ing., **68**:148 ('47). Various methods for detn. of free Cl reviewed. Fe and Mn interfere in colorimetric methods with dimethyl-*p*-phenylenediamine and *o*-tolidine. Fe ion can be fixed in complex by addn. of basic Na pyrophosphate. Mn can be removed by addn. of $CaCO_3$ after free Cl converted into chloramine. Directions embodying these procedures given.—*C.A.*

The Determination of Free Chlorine in Water With Chlorine-sensitive Dyes. Georg Gad & Erna Prieg-nitz. Gesundh.-Ing., **68**:174 ('47). Dimethyl yellow and especially methyl orange more easily decolorized by ac-

(Continued on page 40)



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(Continued from page 38)

tive Cl than methyl red, which has been previously used for analytical purposes. By addn. of KBr quant. detn. of as little as 0.3 ppm. of Cl_2 possible. Sensitivity can be increased to 0.02 ppm. by following modified procedure: Excess of dye added to sample. Cl_2 removed from 2nd sample by addn. of Na_2SO_3. No KBr added to this sample. Dil. soln. of dye then added until color intensity matches that of 1st sample. Difference in amt. of dye used represents that decolorized by Cl_2. Advantage of method is that ferric salts do not interfere. Accurate directions given for detns. in ranges 0.3–2.0 and 0.02–0.3 ppm. free Cl with methyl orange soln., and for range 0.02–0.5 ppm. with methyl orange soln. contg. HBr.—*C.A.*

Determination of Total Iron in Water. GEORG GAD & MARGARETE MANTHEY. Gesundh.-Ing., **71**:27 ('50). Methods for detn. of total Fe with KCNS reviewed and rapid method using KCNS, HNO_3 and $KMnO_4$ described. Dil. 50 ml. of 25% soln. of pure HNO_3 with 150 ml. distd. H_2O, boil, and, after cooling, add 4 ml. of satd. $KMnO_4$ soln. Shake 10 ml. of this soln. with 100 ml. of H_2O to be tested and after 5 min. add 5 ml. 10% KCNS soln. Compare red color with standard. If Mn to be detd. in same sample as total Fe, following procedure proposed: Boil 100 ml. of sample with 6 ml. HNO_3 for 2–3 min., add slight excess of $AgNO_3$ to ppt. chlorides and 0.5 g. $K_2S_2O_8$. Boil until liquid becomes clear. Compare $HMnO_4$ color with standard.—*C.A.*

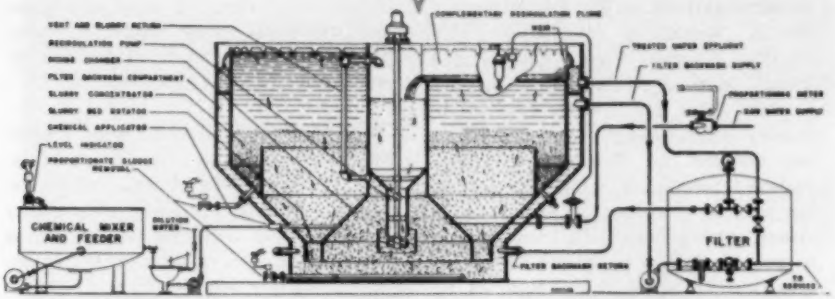
Colorimetric Determination of Lead in Drinking Water. JOHANNES MULLER. Gesundh.-Ing., **70**:407 ('49). Gad's method (*see* preceding abstract) for colorimetric detn. of Pb described and some sources of error discussed. Water to be tested (100 ml.) made to react with 5 ml. of 50% Seignette salt soln., 3 ml. 33% NaOH, 2 drops 10% KCN soln. and 2 drops of 10% soln. of Na_2S, and liquid shaken thoroughly after each addn. After 1–2 min. color which develops compared in Hehner cylinders with standard Pb soln. treated with same reagents. Color generally stable up to 5 hr. Glycerol-contg. Na_2S soln., with Na_2S DAB 6, gives easily reproducible colors whereby glycerol as protective colloid has stabilizing influence upon PbS sol. Operations have to be carried out in order indicated by Gad. Use of humic acid in comparison soln. not advisable. Concn. of water before starting test not required.—*C.A.*

Estimation of Nitrite and Nitrate in Drinking Water. JUAN A. SÁNCHEZ. Mon. farm. y terap. (Madrid), **56**:61 ('50). Mix vol. of H_2O contg. N_2O_3 (1 ml. of soln. 1:100,000) with 1 ml. of 1% resorcinol soln., add 10 drops H_2SO_4, mix and heat at 100°. Red color permits colorimetric estn. In place of N_2O_3, $NaNO_2$ can be used. Nitrates do not give reaction, but if HCl added following H_2SO_4, red color appears.—*C.A.*

Polarographic Determination of Zinc in Waters. SUSANA M. DE SALAS & ROSA S. GRAELLS. Anales Asoc. Quim. Argentina, **37**:208 ('49). Filtered acidified sample (200 ml.) concd. to 50 ml. Polarogram made of 10 ml. composed of 8 ml. of base soln. (125 g. NH_4Cl and 125 ml. concd. NH_4OH made to 1 l.) and 2 ml. 0.01% gelatin soln. (max. suppressor). V concn. must be below 0.6 ppm. Other ions or org. matter do not seem to interfere. Routine sensitivity is 0.5 ppm. Zn; concn. of sample increases sensitivity. H_2O from various Argentine sources in general contains less than 0.05 ppm. Zn. Other methods for

(Continued on page 42)

UNIFORM TREATMENT UNDER VARIABLE LOAD CONDITIONS



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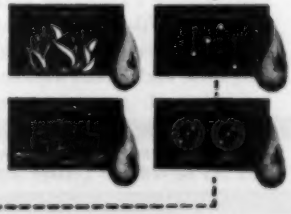

(*Continued from page 40*)

detg. Zn in natural H_2O discussed.—*C.A.*

Continuous Purification of Water for Isotopic Analysis by Density Determinations. R. L. Burwell, W. E. Roake & M. Dole. U.S. Atomic Energy Com., Oak Ridge, Tenn. Method of continuous purification of water for isotopic analysis by density determination described. Water allowed to flow down steam-jacketed tube over which current of air passed. Evaporator tube contains closely fitting helix of nichrome wire to provide longer path and better distribution of liquid flow. Rate of admission of water controlled by degree of penetration of nichrome wire into capillary. Water is condensed and flows down to catch basin whence diverted to collector system.—*P.H.E.A.*

HEALTH AND HYGIENE

A Statistical Study of Illness in Relation to Natural Bathing-Water Quality. Albert H. Stevenson & Theodore D. Woolsey. Paper presented at 77th Ann. Meeting of Am. Pub. Health Assn. (Oct. 27, '49). This study one of series being undertaken by Environmental Health Center to secure epidemiological data correlated with bathing-water quality determinations in order to establish more definitive and acceptable bathing-water guides. Study undertaken at Chicago using 2 resident population groups located adjacent to 2 Lake Michigan bathing areas of different bacterial water quality. Approximately 5000 residents participated in study by maintaining swimming and illness records over 70-day period during summer. Information obtained on eye, ear, nose and throat ailments, skin irritations and gastrointestinal disturbances. Illness among nonbathers in each area served as control. Both bathing areas proved of good quality for natural surface waters and no significant difference in illness rates between bathers in two areas found. However, in comparing occurrence of illness after days of relatively good and relatively poor bacterial water quality, slightly significant positive result found in one area.—*P.H.E.A.*

Tolerance Concentrations of Radioactive Substances. K. Z. Morgan. U.S. Atomic Energy Com., Oak Ridge, Tenn. Review of some elementary equations and procedures involved in determining tolerance concentrations of radioactive substances when taken into human system. This work discussed from viewpoint of methods of radioactive intake and elimination, background radiation, tolerance limits of radiation, nomenclature of radiology, long-lived and short-lived radioactive elements in body, and chain products in body. General discussion of problems illustrating use of equations derived in foregoing subjects included.—*P.H.E.A.*

Tubercle Bacilli in a Watercourse Contaminated With Sewage From a Sanitarium. V. Monaci. Boll. Ist. Sieroterap. Milan., **28**:295 ('49). Effluent from sedimentation basin of 350-bed hospital, canal water receiving liquids, and mud of the canal were examd. for tubercle bacilli. To 1000 ml. liquor were added 2.5 ml. 10% K_2HPO_4 and 5 ml. 1% NaOH soln. Mixt. stirred and 5 ml. 10% $CaCl_2$ soln. added with agitation. After 2-hr. settling of flocculent ppt., clear liquid decanted and centrifuged at 5000 rpm. for 15 min. One part of sediment treated with equal vol. of 12% H_2SO_4 for 20–40 min. and one part with 10% HCl for 10–20 min. After centrifuging 30 min. sediments suspended in 2 ml. physiol. soln. and 0.5 ml. placed in Petragnini medium.

(*Continued on page 44*)

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(*Continued from page 42*)

Isolated strains inoculated into guinea pigs. Tubercle bacilli isolated 4 times from effluent of sedimentation basin (6 samples examd.); 5 times from canal water 50, 100 and 200 m. from point of entry (15 samples examd.) and once from mud collected at distance of 150 m. (2 samples examd.). At 250 m. no bacilli found.—*C.A.*

CORROSION AND CORROSION CONTROL

Zinc Chromate Primers. H. B. KIRKPATRICK. J. Oil & Colour Chemists' Assn. (Gt. Br.), **32**:223 (May '49). This summary of paper read in Australia begins with short history of development of zinc chromate to its present position as most important single rust-inhibitive pigment. Theoretical basis of this superiority lies in fact that iron and steel protected from direct action of water by formation of dilute solution of zinc chromate on surface of metal, due to slight solubility of zinc chromate. Under these conditions, rust cannot form. Importance of proper formulation to insure effective rate of chromate ion extraction stressed. Best vehicle found to be high phthalic linseed oil alkyd.—*Corr.*

Bituminous Coatings for Protecting Iron and Steel Against Corrosion. R. ST. J. PRESTON. Ind. Finishing (Gt. Br.), 715 (June '49). Review of existing information on bituminous coatings generally. These coatings of three types: wholly bituminous-base media, modified bituminous-base media, and pigmented and filled compositions. Various substances which can be added to tar or bitumen base to improve weather resistance, adhesion and appearance discussed. Comparison of metal powder pigments shows that zinc chromate among best of these for protection of light alloys and steel. Zinc oxide mentioned as basic corrosion inhibitor. Suggested that use of cheap bituminous media, together with more expensive types of pigments, might give protective composition at lower cost than one containing cheaper pigments and more expensive oil-type media.—*Corr.*

Nonmetallic Coatings for the Protection of Steel. ANON. Products Finishing, **12**:10:88 (July '48). Several nonmetallic protective schemes, including paints, sprayed coatings and other nonmetallic coatings, applied to structural mild steel and exposed to atmospheric weathering up 5 yr. and to sea water for maximum of 2 yr. 2-coat painting schemes applied to surfaces pickled by sulfuric-phosphoric acid treatment in good condition after 5-yr. weathering. Dull, gray phos-

(*Continued on page 46*)

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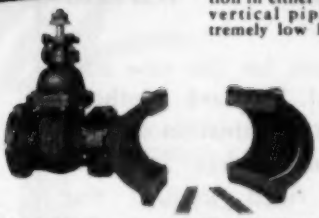

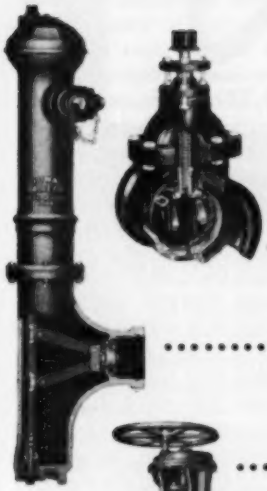

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(Continued from page 44)

phate film in itself has little protective value except indirectly as excellent paint base. When applied to specimens partially descaled by weathering and then wire brushed, one paint scheme failed in 1.6 yr. or less; pretreating this type of surface with proprietory phosphoric-chromic acid inhibiting wash before painting did not improve durability of the coating. In atmospheric test, lanolin-base paints hardened with synthetic resin and containing chromate pigments were satisfactory as primers over pickled steel. Sprayed-on paint containing no volatile matter effective in industrial atmosphere, but showed signs of breakdown after 5 yr. in nonindustrial atmosphere. Sprayed-on cement-asbestos, ¼" thick, permitted no corrosion after 5 yr. Heavy coatings of sprayed bitumen, alone or mixed with rubber or zinc, were satisfactory when continuously immersed in sea water. Addition of glass to sprayed zinc coatings did not appreciably affect their performance in sea water. Tar-tallow-lime mixture, applied hot, failed after 3 yr. in industrial atmosphere; this life comparable to that of single paint coat of about equal weight. Rubber-wax sheathing gave good results in industrial, but irregular results in marine, atmosphere. Vitreous enamel coatings in perfect condition, apart from minor mechanical damage, after 5 yr. in either atmosphere or 2 yr. in sea water. Painting systems studied comprised 2- and 4-coat combinations of red lead or red oxide in linseed oil, proprietory scheme of paints bound with alkyd resin media, and schemes containing prime coats of resin-reinforced lanolin-base paints. Sprayed coatings tested included paint with no volatile constituent, cement-asbestos used for insulating purposes, powdered-bitumen mixtures, and mixture of powdered zinc with silica glass. These powdered mixes sprayed on with modified

(Continued on page 48)

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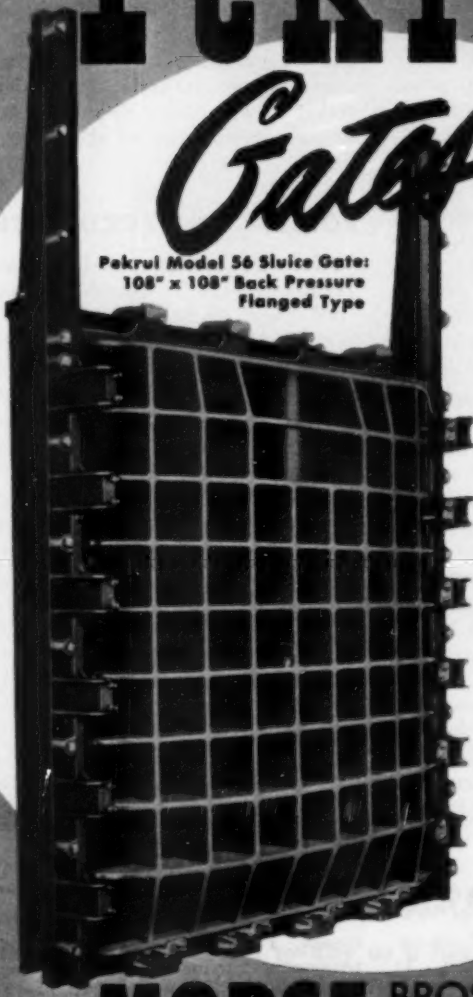

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(*Continued from page 46*)

powder-metal spraying pistol. Of other coatings tested, tar-tallow-lime mixture applied hot and rubber-wax mixture could be molded to give continuous sheath. Phosphate pickle process involved descaling of steel samples by immersion for 15–20 min. in 5–10% sulfuric acid at 60–65°C., rinsing by dipping twice into water at 60–65°C., immersion for 3–5 min. in bath containing about 2% free phosphoric acid and 0.3–0.5% iron at 85–90°C., followed by rapid drying.—*Corr.*

Chemical Aspects of Underground Corrosion and Corrosion Prevention. I. A. Denison. Proc. Am. Gas Assn., **30**:517 ('48). First part of article deals with underground corrosion of ferrous metals and includes sections on pitting and effect of chemical constitution of soil and alloy composition of metal on corrosion. Section devoted to corrosion of zinc and galvanized materials contains results of 10-yr. underground exposure test. Found that, in several soils, losses in weight of galvanized specimens much less than those for either zinc or steel specimens; this result, it is suggested, must be effect of iron-zinc alloy layers. Corrosion of copper, brass and lead also discussed. Zinc anodes for cathodic protection gave good results in most soils, and it is suggested that use of high-grade zinc is advantageous. Use of aluminum and magnesium anodes for this purpose dependent on proper choice of alloy and chemical backfill.—*Corr.*

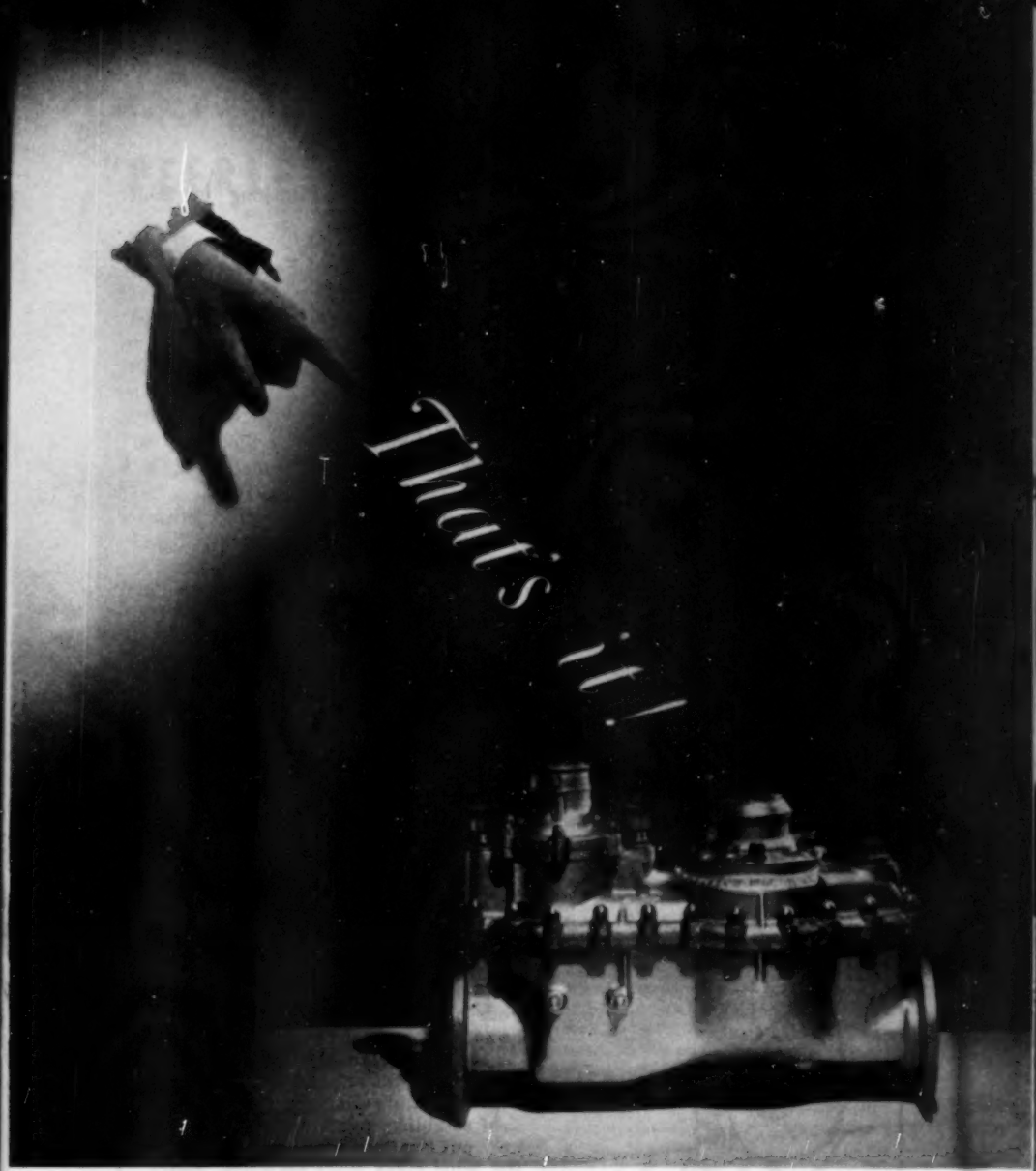
Aerobic Microbial Corrosion of Water Pipes. Erik Olsen & Waclaw Szybalski. Acta Chem. Scand., **3**: 1094, 1106 ('49). (In English.) Electrochem. nature of corrosion and role played by microorganisms, especially iron bacteria, discussed. There is primary formation of "differential aeration cell" by iron bacteria. Feltlike structure of sheaths of bacteria causes mech. strengthening of "tubercle," which becomes resistant to flow of water in main. Bacteria cause further anaerobic conditions, increasing potential between iron surface under and outside of bacteria, whereby corrosion is increased. Bacteria have minor effect in establishment of anaerobic conditions under tubercle during main period of corrosion; they cause avg. increase in corrosion of about 10%.—*C.A.*

BOILERS AND FEEDWATER

Boiler Maintenance—Feedwater Treatment. L. F. Collins. Iron & Steel Engr., **26**:9:70 (Sept. '49). In field of municipal water supplies, estimated that "extra" pumping costs resulting from roughing of inner surface by corrosive attack amounts to about 10% of gross revenue of average water utility. Formula given for determining maintenance labor required to descale heat-transfer equipment. Investigations in electrical utility field attest that cost of tolerable amounts of slime in condensers is of order of $50–$70 per year per 1000 kw. of capacity. By means of corrosion tester, which is diagrammed, one can determine in 30 days or less rate at which any selected metal will be attacked by contacting medium under actual operating conditions. Slime and scale prevention and degasification discussed.—*Corr.*

Treatment of Locomotive Feedwater. J. Leick. Werkstoffe u. Korrosion, **1**:64 ('50). If water with temporary hardness used, alky. no. of boiler water must be kept under 100. Feedwater should also show no excess alky., and hardness must be equal to alky. In softening by pptn. methods, no excess of chemicals should be used.

(*Continued on page 50*)



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(Continued from page 48)

Untreated water with high carbonate hardness must be decarbonated before softening by base exchange, or it should be treated by H exchange. Softening of water within boiler possible by use of phosphates, such as hexametaphosphates, for prevention of hard boiler scale. Foaming caused by increased salt content can be controlled by decantation through special valves. O corrosion avoided by proper feed-in arrangements or by addn. of Na_2SO_3 in emergency.—*C.A.*

Investigation of Water Tube Boiler Characteristics. S. I. MOCHAN & D. F. PETERSON. Eng. & Boiler House Rev., **65**:74, 83 ('50). Various methods for securing min. steam contamination by appropriate design of boiler circuit discussed, and description given of novel method of steam purification involving double washing of boiler steam.—*C.A.*

Desilicatization of Feedwater. A. V. SINYAVSKII. Elek. Stantsii, **20**:25 ('49). Limit of tolerance 75 ppm. SiO_2. Large part of it removed by lime treatment, followed by settling and filtration. Total effect, at 16° and 40°, is elimination of 48.5 and 69.0%, resp. Lime treatment alone, at 40°, 60°, and 80°, resp., resulted in 32, 38.3, and 45.5% desilicatization. Used crushed-marble filters more effective than fresh ones, owing to their enrichment in MgO and SiO_2; evidently, Mg silicate formed on grains has higher adsorptive capacity for SiO_2. High degree of desilicatization obtained by use of calcined dolomite, converted into strong soln. of $Mg(HCO_3)_2$. With original SiO_2 content of 14 ppm.,

(Continued on page 52)

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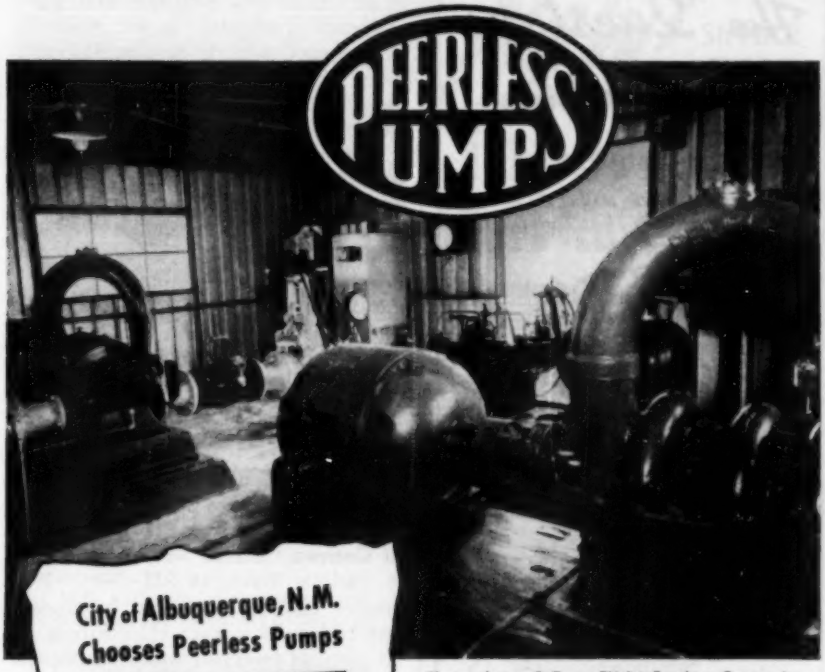

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at 20°, treatment with this soln. gave efficiency of 61–63%; at 40°, 80–87%, as compared with 32–33% at 40° with lime. Optimum dose 10–12 mg. MgO/mg. SiO_2. Essential point is conversion of MgO into ionic form.—*C.A.*

Modified Sodium Silicate for Industrial Water Softening. R. R. McDowell. Ind. Chemist, **26**:51 ('50). Silica sols used as coagulants in treating water of low Mg content. Procedure given for prepg. sol from sodium bicarbonate and sodium silicate. Performance in both batch and continuous plants discussed.—*C.A.*

DISINFECTION

One Year's Daily Analysis of Water of Lake of Geneva and the Drinking Water Delivered to the Population of Geneva. Emile Novel. Schweiz. Z. Path. u. Bakt., **12**:523 ('49). Extensive analyses presented in numerous tables show that chlorination of 0.1 ppm. of reservoir water insufficient to sterilize it. Water further contaminated along its path to fountains. Following remedies suggested: filter plant to eliminate animal and vegetable matter prior to chlorination, establishment of a new sterilizing plant, thorough cleansing and disinfection of pipelines.—*C.A.*

A Comparative Study of the Sterilizing Action of Chlorine and Ozone on Water of Lake of Geneva From Petit Lac. E. Novel & T. P. Buffle. Schweiz. Z. Path. u. Bakt., **12**:544 ('49). Data of preliminary expts. presented in tables. Use of ozone as disinfectant preferred over that of Cl or its derivs. because: [1] it may be added in excess without ill effects in emergency: [2] its action much faster than that of Cl; [3] bactericidal control easy; [4] readily available from atm. O.—*C.A.*

(Continued on page 54)

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The Effect of Chloramine on the Miracidia of *Schistosoma mansoni*. NELSON BIAGGI & RAFAEL PIRAZZI. Puerto Rico J. Pub. Health & Trop. Med., **24**:246 (Mar. '49). Concentrations of chloramine in water, varying from 0.3 to 0.89 ppm., had definite effect on viability of miracidia of *S. mansoni*. Chloramine concentrations of 0.45 ppm. inactivated miracidia in avg. time interval of 7.2–8 minutes. Miracidia lost their motility in chloramine concentrations of 0.89 ppm. in maximal time period of 5¼ minutes.—*P.H.E.A.*

MILITARY SUPPLIES

Purification of Water on a Small Scale. H. J. ANDERSON. J. Roy. Army Med. Corps, **93**:4:187 (Oct. '49). Provision of safe water supply for men on active service of vital importance for success of any campaign. This realized by army authorities at early date. Paper is excellent historical account of water purification methods developed for small units of troops in field. Comparative absence of facilities for purification in South African War, but progress in that direction rapid and results very satisfactory during last 50 years. Formerly men separated from their water cart were told to boil all drinking water. Nesfield's early success with iodine at beginning of this century followed by Horrocks' method of sterilization with ¼ bleaching powder and ¼ quicklime. For smaller groups of men tablets of acid sodium sulfate and later "Halazen" (p-sulfondichloraminobenzoic acid) used. From 1918 onward ammonia-chlorine process developed by Harold for large-scale purification, but during recent war method of superchlorination and dechlorination (Mackenzie) adopted as standard procedure. Latter method also preferred for individuals by developing "Halazone" method introduced originally by Dakin and Dunham. Individual outfits containing white sterilizing tablets and blue dechlorinating tablets used freely during recent war, but in certain circumstances, such as jungle warfare, limitations of outfit apparent. For clarification, cloth reel filter designed by Horrocks superseded by Meta- and Stellar filters, and, for use by paratroops, Millbank Filter Bag of Elliott and Hall proved very successful. Research continuing on methods of purification, particularly with regard to possibility of chemical poisons and radioactive elements in water. Ideal method must be simple and not series of processes. Any material required must be light and compact as burden of fighting soldier must be reduced to a minimum. It must also be durable to withstand all conditions in all weathers and climates from tropical to arctic. Similarly, any chemicals used must be stable under these conditions for considerable periods.—*B.H.*

TREATMENT—GENERAL

Treatment of Arsenical Waters With Lime. ROGELIO A. TRELLES & FORTUNATO D. AMATO. Rev. Obras Sanit. Nacion (Argentina), **13**:95 ('49). In some locations only water supply contains relatively high As content. In some regions waters contg. 0.15–0.25 ppm. As used without reported ill effects, despite accepted limit of 0.10 ppm. As for potable water. Usual removal of As is by Fe or Al floc, followed by filtration and pH adjustment. Found that treatment with CaO alone, pptg. $CaCO_3$ or $Mg(OH)_2$, reduces As content. 3 examples given. Deep well water before and after treatment with 156 ppm. CaO had following properties, resp.: pH, 7.9, 10.8; total hardness as $CaCO_3$, 167, 102; As, 1.0, 0.16 ppm. Adjustment of pH of treated water by recarbonation ad-

(*Continued on page 56*)

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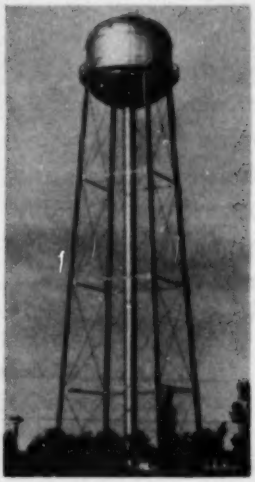

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(Continued from page 54)

vised. Turbid waters cleared by this treatment, which does not increase sulfate in water.—*C.A.*

Iron and Manganese Removal at Lake Charles. W. B. GURNEY & G. H. WEST. Proc. 12th Ann. Short Course. La. State Univ. Eng. Expt. Sta. Bul., **18**:31 ('50). Aeration, chlorination, settling and filtration reduced iron from 1.8–2.8 ppm. in well water to 0.04–0.28 ppm. in filter effluent, and Mn from 0.3–0.7 to 0.05–0.21 ppm. Settling basin sludge mostly iron, and floc retained by filters showed Fe:Mn ratio of 10:1. Incrustation on filter sand had Fe:Mn ratio of 1:10. As total Fe and Mn did not change through settling basin, entire load passed to filters. Filter backwash effluent never cleared, owing to erosion of Mn film. Reaction time insufficient and Cl dosage partially effective. Lab. tests showed removal of Fe by Cl to be fairly fast, but needed time and excess of Cl. Mn removal extremely slow and incomplete even with excessive Cl. Both Fe and Mn readily removable by ion exchange or lime treatment. Coated sand grains appeared as possible method, but permitted sol. Mn in effluent toward end of run from blanketing action of penetrated iron floc. Copper sulfate accelerated oxidation of both Fe and Mn, complete removal of Mn being obtained in less than 30 min. if Cl demand slightly oversatisfied. In plant, copper sulfate (0.2 ppm. Cu) fed ahead of aerators as catalyst and Cl applied after aeration; no Cu appears in filter effluent. Filter backwash drainings clear up quickly. In effluent, Fe now stands at 0.02–0.08 ppm., and Mn at 0.00–0.04 ppm.—*A. A. Hirsch.*

Purification of Water by Flocculation. O. SAMUELSON. Trans. Royal Inst. Tech. (Sweden), p. 1 ('47). Study made of flocculation of water contain-

(Continued on page 58)

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(*Continued from page 56*)

ing humus matter. Comparative tests made on water devoid of phosphates and on water containing phosphates show that presence of *o*-phosphates impedes flocculation of humus matter. Experiments have been carried out on aluminum sulfate, aluminum nitrate and cadmium nitrate. Found that impeding action of orthophosphates due to fact that part of ions precipitated in form of basic phosphates. Test results indicate that flocculation of humus matter in water bears considerable resemblance to precipitation of basic salts.—*P.H.E.A.*

GROUND WATER

Ground Water Conditions in the Smoky Hill Valley in Saline, Dickinson and Geary Counties, Kansas. BRUCE F. LATTA & H. A. STOLTENBERG. Kansas Geol. Survey Bul., **84**:1 ('49). Most large water supplies in area obtained from wells that tap Quaternary alluvial deposits, 30–90′ thick, beneath valley plains. Logs of 146 test holes and wells included. Ground waters hard to very hard, ranging from 274 to 1980 ppm. Of 64 samples analyzed for Fe, 51 contained more than 0.1 ppm., 32 more than 1 ppm. More than 10,000 ppm. chloride found in some ground waters.—*C.A.*

Variations in CO_2 in Ground Waters. H. SCHOELLER. L'Eau (Fr.). **37**:77 (May '50). Quantity of CO_2 in ground waters diminishes with rising altitudes. Variations function of climate; quantity of CO_2 increases gradually from northern France south to center of Tunisia, where it begins to decrease until Sahara is reached.

(*Continued on page 60*)

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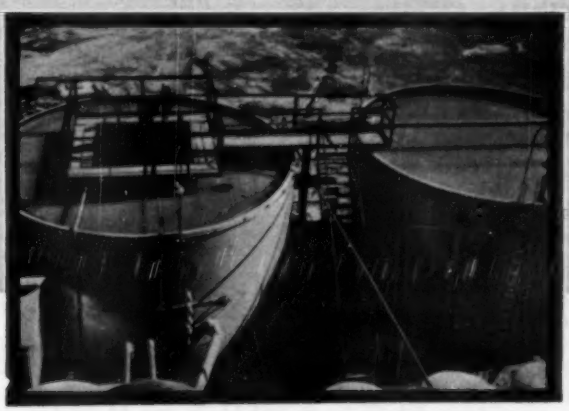

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(*Continued from page 58*)

Analyses of water in mountainous regions (Pyrenees and Alps) show that CO_2 and carbonates decrease with altitude and possibly with temperature. General reduction in CO_2 perhaps related to decrease in microbial activity in soil. Evidently amounts of rainfall not without influence, because greater rainfall dilutes concentrations of CO_2. In valleys, CO_2 concn. about twice that in mountains. However, magnitude of CO_2 concn. not constant throughout given region. Other factors are rate of water movement in soil, aeration and exposure; however, these of minor importance in subsurface waters, hence CO_2 concn. in ground water primarily function of altitude and latitude.—*Willem Rudolfs.*

SWIMMING POOLS

Diatomaceous Earth Filtration for Swimming Pools. R. F. HEATH. Wtr. & Sanit., **88**:7:17 (Jul. '50). All pools in Toronto must have modern filtration and chlorination facilities. Harrison Baths, operated by city, equipped with hypochlorinator and diatomaceous earth filter in '48. Latter probably first such pool installation in Canada. Pool capac. 50,000 gal., recirculated every 5 hr. Filter, cylindrical steel shell lined with plastic, 6'3" high and 26" diam., contains 13 cylindrical elements consisting of 2 concentric 110-mesh monel metal screens 48" long, inner and outer 3.5 and 4.25" diam., resp. Filtering surface 104 sq.ft., filtration rate 2 gpm./sq.ft. Diatomaceous earth for precoat 7–8 lb. per 100 sq.ft., layer about $\frac{1}{8}$" thick. Continuous feed 5–10 ppm. Backwashed with pool water when loss in head 25–30 psi. 15 min. to wash, precoat and restore to service. Water recirculated within filter after precoating until effluent clear. Runs 2–7 days, depending on load. Removal of coarse suspended matter, particularly hair, prior to filtration essential. No coagulant used. Effluent clear and colorless.—*R. E. Thompson.*

Results of the Disinfection of Open Swimming Pools by the Electrocatadyn Process. S. HOFFMANN. Strasse u. Verkehr, **33**:94 ('47); Chimie & Industrie, **61**:44 ('49). Treatment of swimming pool water with Ag salts involves first "impregnation" with several 100 γ per l. followed by "activation" by at least 50 γ per l. *Esch. coli* content and total counts considerably reduced by this treatment which is both economical and effective.—*C.A.*

TASTE AND ODOR CONTROL

Odor and Taste Control in a Lower Mississippi River Supply. NEZEM J. LORIO. Proc. 12th Ann. Short Course. La. State Eng. Expt. Sta. Bul., **18**:35 ('50). Taste and odor problems, nil until 5 yr. ago, steadily increasing. For past 3 summers and autumns, at low river stages, medicinal taste, with threshold odor from 10 to 40, controlled best by activated C split before coagulation with alum and lime, and after floc formation. Early in winter of '49, with turbidities from 400 to 700 ppm., medicinal taste corrected by adding all C after flocculation to prevent absorption of C by turbidity particles. Cl doses up to 5 ppm. unsuccessful.—*A. A. Hirsch.*

Activated Carbon. ANON. Wtr. & Wtr. Eng. (Gt. Br.) **52**:123 (Mar. '49). Carbon not only substance that possesses ability to adsorb on its surface all manner of substances, but possesses it to higher degree than any other. Not until World War I was any real progress made in mfg. carbon with greatly enhanced degree of

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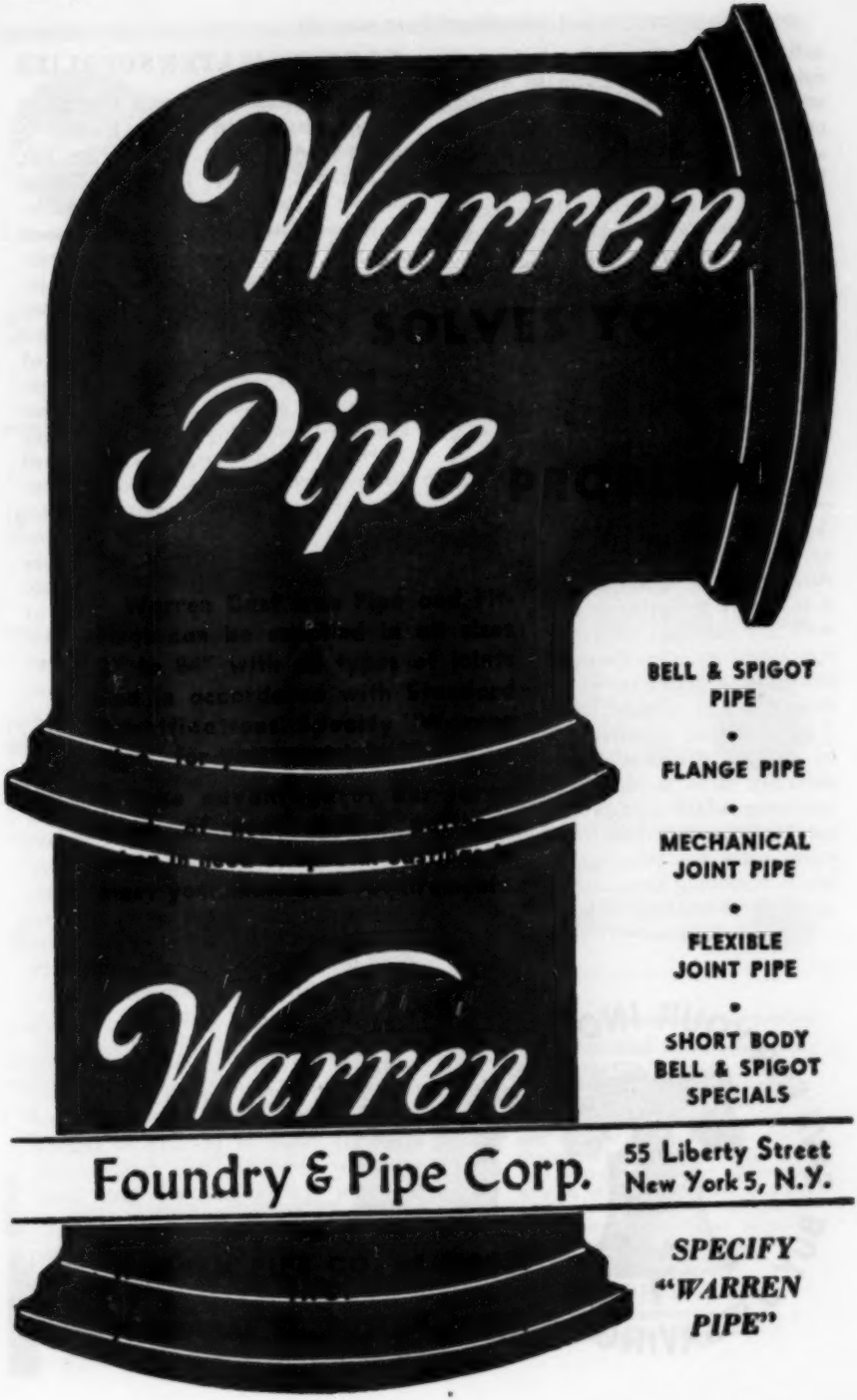
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(*Continued from page 60*)

activity. Any material which yields coke on being heated can be used to make activated carbon. Cocoanut shell once favorite material but demand now so great that coal, peat and wood largely used. Material carbonized and resulting coke quenched and screened. It is then put in second retort and heated in current of steam for up to 10 hr. at 1000°C. Result is activated carbon of about 12% of weight of original material. Various modifications of this basic process in use. Modern active carbons have capac. between 50 and 200 times that of wood and bone chars formerly used. Substance used in water purif. to remove excess chlorine or various tastes and odors to which water supplies liable. Activated carbon may be used either as granular or powdered material. Advantage of granular bed is that it is always in operation and will cope with any contamn. which arises without warning. In England dose of powdered activated carbon usually less than 10 ppm., usually between 2 and 5 ppm., but in America higher doses of 20 ppm. frequently used. Filters naturally have to do extra work in removing added carbon but this has not been found serious. pH value of water often has effect on eff. of carbon in removing tastes. Phenolic substances best removed at low pH value. —*H. E. Babbitt.*

FOREIGN WATER SUPPLIES

Water Works Economics [Gt. Br.]: A Symposium in Three Parts. J. Inst. Wtr. Engrs., **4**:99 (Mar. '50). **I. Finance.** S. W. Hill. 1. *Capital finance.* Parliament has most effective control over finances and general conduct of company water undertakings through control of company capital. Amount of capital company may raise from time to time is limited, and there are restrictions on ratio of dividend and methods of raising capital, as well as other controls. 2 main classes of proprietary capital: ordinary shares and preferred shares. Third main source of company's capital consists of loans—either mortgages, debentures or debenture stock. Essential feature of water company finances is that although capital powers may derive from particular program of capital works, raising of block capital is in no sense earmarked against cost of particular job. Another important distinction is that company's capital permanent. Until recently stocks and shares of well established, larger companies marketable at about 4% yield. At present, due to threat of nationalization, ordinary shares cannot be issued to yield much less than 5 per cent. Capital finances of local-authority undertakings provided entirely by loans of one form or another. With few exceptions, all local-authority loans repayable, that being cornerstone of local-authority capital finance. Capital finance of joint water boards composed of local authorities almost identical in principle with that of individual local authorities. Local-authority financial practice in regard to major renewals and replacements does not always conform with basic principles. Renewal of asset is properly subject of further borrowing provided original loan repaid. Other methods of capital finance available to both types of organizations: [1] capi-

(*Continued on page 64*)

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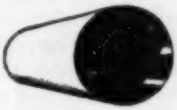

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(*Continued from page 62*)

tal contributions, [2] capital expenditures out of revenue and [3] reserves. First of these includes lump-sum governmental grants and contributions by potential consumers. 2. *Provision of funds.* Water Works Clauses Act of 1847 permitted setting up of reserve fund out of profits after paying dividends. Maximum accumulation of reserve fund fixed at 10% nominal capital. 12.5 per cent limitation on original cost would not represent, at present-day prices, more than, say, 5 per cent of replacement cost. Many local acts authorize local authorities to set up reserve funds, in no way connected with sinking funds but available to meet extraordinary claims. 3. *Charging powers.* Water Act of 1945 seeks to introduce common form of water rate. Appears now that many years will elapse before uniform method of charging in force throughout country. Control over charges of statutory undertakings constitutes another important part of system of parliamentary regulation. Domestic charges take variety of forms though with one common basic principle—charges leviable in relation to annual assessed value of houses supplied. Metered supplies charged per 1000 gal., generally subject to minimum payment. Collection generally on half-yearly basis, though occasionally quarterly. Fair balance between domestic and trade sources can rarely be determined by formula. Local authority faced with temptation to work on deficiency basis—balance being borne by general body of taxpayers—to avoid or curtail its liability to income tax. 4. *Guarantees.* Water Act of 1945 permits local authority to guarantee water company amount of annual water rates for premises supplied by main extensions up to ½ of capital cost for maximum period of 12 yr. 5. *Government grants.* Ministry of Health may contribute to expenses of local authority in improving or providing water supply in any rural locality. 6. *Income tax.* Both company and local-authority water works undertakings subject to income tax on profits. 7. *Tax liability.* Important item in expenditure accounts of water undertakings is liability to taxes, which not infrequently represent largest single item of expenditure. Courts have upheld revenue method of assessment by which hypothetical rent determined according to profits which tenant of undertaking could be expected to obtain from it. 8. *Acquisition of water undertakings.* Transfer of ownership highly complicated subject, involving joint boards, compensation of dispossessed owners, exchange of shares, liquidation of loans and so forth. 9. *Bulk supplies.* Settlement of prices for bulk supplies from one undertaking to another involves complex problems. It is usual to provide that bulk supplies shall be afforded at cost price. **II. Costs.** E. G. B. GLEDHILL. "Costing" (i.e., cost accounting) may be defined as classification, allocation and proper recording of expenditure to determine cost of particular service and for presentation of suitably arranged data for purposes of control and guidance of management. Cost accounting makes it possible to analyze and classify costs of treatment, pumping and so on; to indicate to management inefficiencies and other losses; to provide for cost comparison as guide for future; to record relative costs of operation of engines, motors and the like; to provide continuous inventory; and to compare expenses with some standard. Cost accounting should suit general organization of undertaking, avoid overelaboration and cover all operations of undertaking. Forms to be filled in by foremen and other workers should be simple. Difficult, if not impossible, to make true comparisons of costs between undertakings without uniform system of cost accounting.

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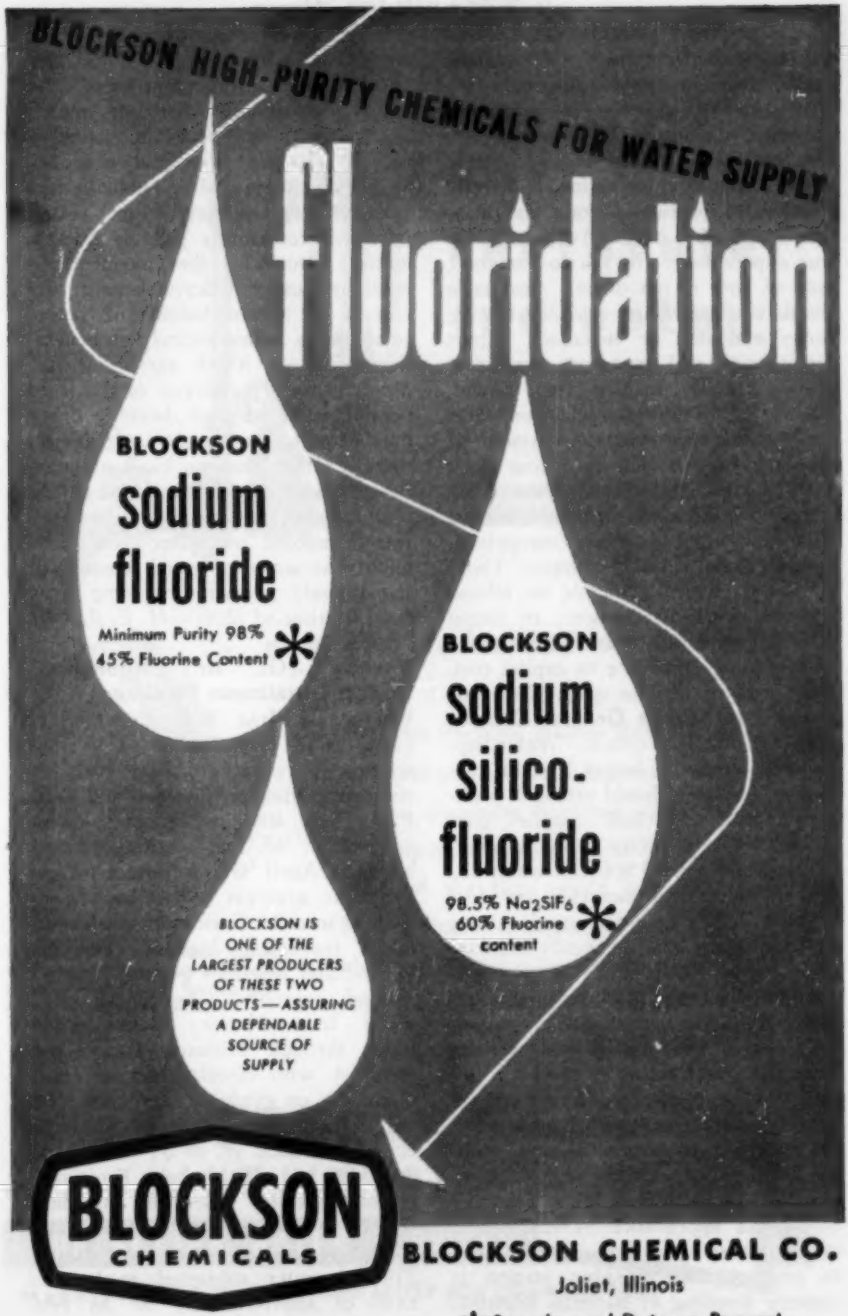

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(*Continued from page 64*)

Cost accounting system most favored for water undertakings is "operating cost system" in combination with "job cost system." Former is system of unit-cost accounting whereby expenditure on various operations of routine nature, such as chlorination, is directly charged to particular code classification arranged to cover all types of routine expenditure. In job cost method, unit of cost is job order. Cost code should be flexible and capable of being easily extended or curtailed. Apart from labor and transport, operating costs normally include fuel, power, lubricating oil and chemicals for water treatment. Most common system of checking time is time-recording clock with weekly time sheet for each worker. Overhead includes indirect labor and other expenses, comprising both fixed and variable charges. There is no established principle on allocation of overhead charges; in fixing rates, method most favored seems to be spreading according to capital cost, cubic capacity or floor space of various works. **III. Some General Considerations.** H. R. LUPTON. Water supply authorities no longer vie for customers, but they should establish peak-period rates for bulk supplies purchased by one utility from another. Cooperation needed between water authorities and manufacturers and fuel suppliers. For example, specifications for machinery have generally been incomplete or too precise. Large proportion of standby machinery can generally be justified to assure continuity of service. Division of cost between state and water authority to obtain immunity from sabotage deserves careful debate. Extent to which expenditures are justified to obtain absolute reliability of water supply quality requires careful investigation. False economy to neglect appearance of machinery, but, on other hand, there is no reason to pretend that pumping station is country dwelling or baronial mansion. Use of slower speeds of machinery to reduce noise at expense of first cost and efficiency is to be deprecated. No expenditure of water customers' money for publicity is justifiable except to inculcate public care and economy. Whole cost of providing public service falls on users of that service. Mode in which community pays is internal matter. Desirable that payments be made by those who derive benefit. Incorrect to regard burden of reconstruction as falling entirely on generation of users which carries it out. Most customers charged on basis of taxable value of their dwelling or on number of taps or water-using devices therein rather than on basis of quantity of water used. Burden of capital commitment can generally be most fairly imposed on water-using community as series of equal annual (or semiannual) payments covering beneficial lifetime of plant.—*H. E. Babbitt.*

Vyrnwy [Gt. Br.] Aqueduct—Fourth Installment Pipeline. W. F. WHITE. J. Inst. Wtr. Engrs., **4**:13 (Feb. '50). Construction of Vyrnwy scheme for supply of Liverpool and environs authorized in 1880 and 1920. Plans for 4th installment pipeline adopted in '45, and section of work begun in April '47. Aqueduct follows hydraulic gradient only when necessary to tunnel. Greater part of aqueduct traverses highest available ground and pipelines generally follow ground contours. Aqueduct draws water from Vyrnwy Res. Water flows through Hirnant Tunnel for 3842 yd. with circular section (min. diam. 7′) on grade of 2.04′ per mile. Alternative drawoff from reservoir consists of 2350 yd. of 54″ steel main and 3308 yd. of 7′ tunnel. From outlet of Oswestry reservoir, line falls steeply in 750 yd. to filtration plant, consisting of 23 slow sand filters. Filtered water subjected to boosted head of approximately 60′ by cen-

(*Continued on page 68*)

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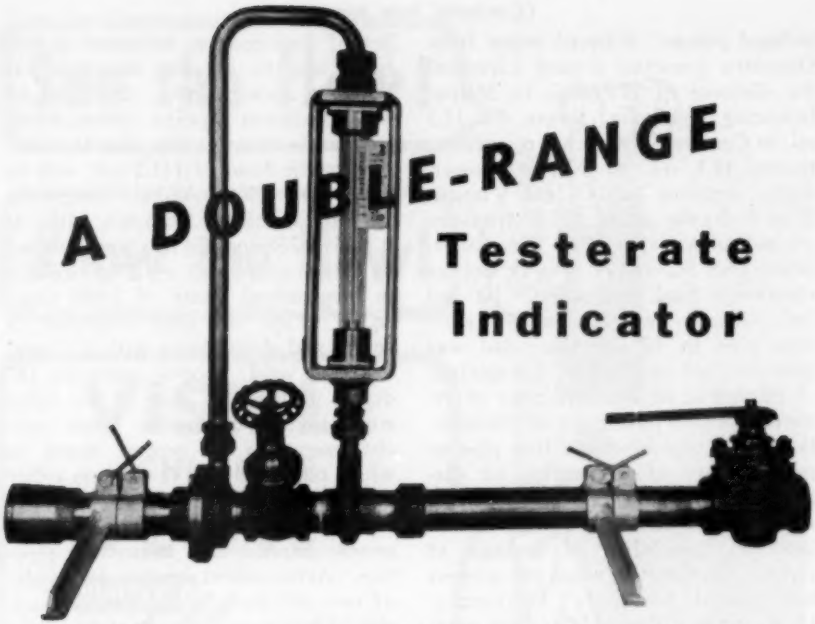

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(Continued from page 66)

trifugal pumps. Filtered water from Oswestry conveyed toward Liverpool for distance of 17.78 mi. to Malpas balancing reservoirs; thence for 11.5 mi. to Cotebrook balancing reservoirs; thence 11.1 mi. to Norton Tower. Latter contains 650,000 gal. (Imp.), is on hydraulic gradient, 110 ft. above ground surface at el. 330. From there, water goes 9.2 mi. to Prescot storage reservoirs, final destination. 1st and 2nd pipelines were 42″ and 39″ cast-iron pipe in 12′ lengths. 3rd was bitumen-lined steel pipe. Comparison of efficiencies of pipelines after 16 yr. shows decided advantage of bitumen-lined steel pipe over cast-iron pipe as regards rate of diminution of discharge. In large-diam. steel pipelines with spigot and socket joints, flexion increases possibility of leakage at joints. Welding by metal-arc process has proved uniformly satisfactory. However, it is desirable to limit number of free ends to minimum practicable and to prevent movement at bends by anchor blocks. In design of 4th installment pipeline, circumferential tensile stress in pipe, due to maximum static head of 141.5 psi., will be 3.032 tons (long)/sq.in. Longitudinal stress, taking Poisson's ratio at 0.26, is 0.758 tons/sq.in.; stress caused by temperature fall of 25°F. results in longitudinal stress of 2.838 tons/sq.in. Type of joint employed is spigot and short sleeve with $\frac{7}{16}$″ convex fillet weld. Access manways, 18″ diam., provided as part of air valve connections. Expansion joints consist essentially of central sleeve in which pipe ends free to move in either direction. In construction of other pipelines, provision made for cross-over connections to future 4th pipeline. Arrangement consists essentially of two 24″-diam. pipes, one on each side of main stop valve, at right angles

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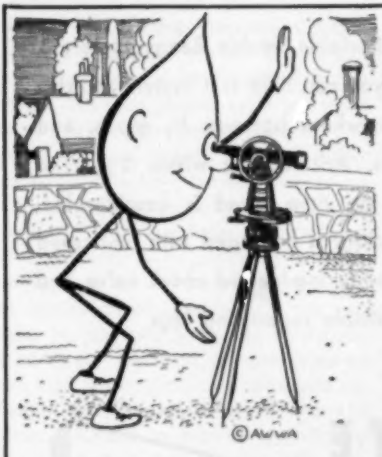

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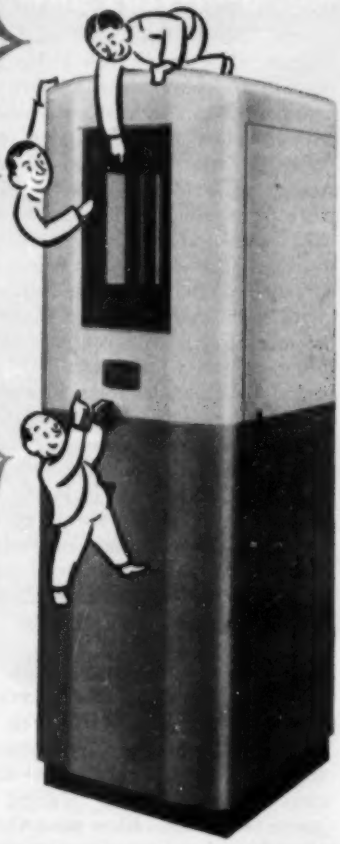

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(*Continued from page 68*)

to pipelines and connected to each through 24″-diam. horizontal sluice valves. Steel plates used conform to British Standard 534–1934; shot blasted to insure clean surface; hot, prime coated in bath of pure bitumen; with finished bitumen lining of ¼″ thickness run into pipe at 440°F. Ability of welders is tested, prior to work on pipeline, by having them prepare sample specimens. Welding of pipeline is by electric arc using direct current. After welding, pipes are tested with water pressure of 300 psi. Surface of metal between ends of spun lining is then warmed and prime coated. Welding of joints at each side of bends is deferred until setting of concrete, to permit slip. Avg. cost of welding one joint complete, in bitumen lining and sheathing, including additional excavation for sheathing mold, is £7 5*s*. Mathematical methods and examples for determination of anchorage length and thrusts at bends given. —*H. E. Babbitt.*

The Ashford Common [Gt. Br.] Filtration Works. F. TATTERSALL. J. Inst. Wtr. Engrs., **4**:76 (Feb. '50). Works will have reliable continuous output of 90 mgd. (Imp.) of filtered water. Water will be received from Queen Mary Res. Slow sand filtration was adopted using micro screens instead of primary filters. There are 28 rotary micro screens, each 10′ in diam. and 10′ long, of Glenfield and Kennedy type, with gunmetal frame covered with steel micromesh, rotating at linear drum speeds of 20–50 fpm. Water flows outwards through screen. Screens washed continuously by ribbons of water impinging on projecting top of screen, wash water being collected in trough inside of screen. There are 32 slow sand filters, each 300′ × 112′, operated at 4 gph. (Imp.)/sq.ft. Filtered water passes to chlorinating points and to 2 contact and balancing tanks, designed for 2-hr. retention for chemical treatment, with balancing capacity of 2 mil.gal. (Imp.) in each tank. Water then flows to high-lift pumps, being dechlorinated on way, if necessary. Superchlorination up to 2.5 ppm. will be used as terminal treatment, with dechlorination with SO_2, if necessary. Pipes and mains are of sizes up to 8′ with capacity up to 200 mgd. (Imp.). Class C steel pipes, bitumen-lined and sheathed, will be used for high-pressure mains. Low-pressure pipes larger than 48″ diam. will have thin steel shell surrounded with 9″–12″ of concrete. Smaller low-pressure mains will be of cast iron. Main control valves are usually 6:1 spur-geared sluice valves with diam. 80 per cent of main. Complete system of electric recording venturi meters will be installed. Gravel subsoil for filter and contact tank has been stabilized with about 50 lb. Portland cement per sq. yd.—*H. E. Babbitt.*

Some Mechanical Aspects of the Ashford Common [Gt. Br.] Pumping Station. R. H. TRIVESS-SMITH. J. Inst. Wtr. Engrs., **4**:83 (Feb. '50). Purpose of pumping station is to pump 200 mgd. (Imp.) stored water to filtration works at Ashford Common and 90 mgd. (Imp.) of filtered water into distribution system. Comparison of costs per whp./hr. for self-contained, steam-driven pumping station with electrically driven pumps powered from outside source, including adequate prime-mover-driven standby and load-relieving plant, showed: running costs, 0.91*d*. and 0.79*d*., respectively; capital costs, 0.52*d*. and 0.70*d*., respectively. Machinery to be installed will consist of electrically operated pumping plant, diesel alternator load-relieving units, combustion turbo alternators for standby electrical supply, high-tension switch gear and transformer, electrical control gear and miscellaneous services. There are 8

(*Continued on page 72*)

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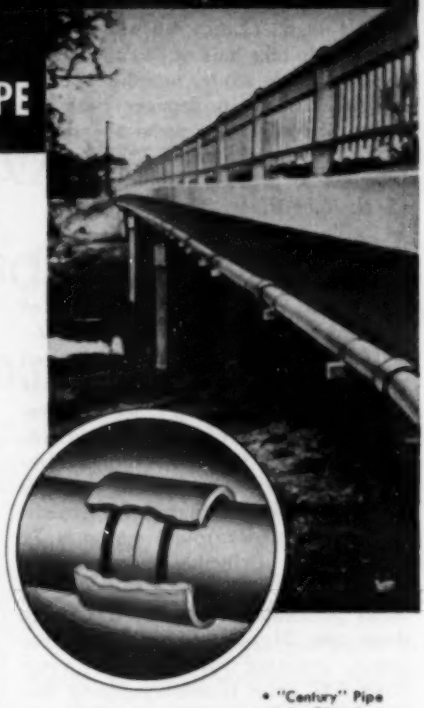

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(*Continued from page 70*)

vertical-spindle, low-lift pumps with capacity of 180 mgd. (Imp.) and 12 similar high-lift pumps with capacity of 204 mgd. (Imp.). Units will be operated to take half of day's load during daytime in winter months with use of diesel plant in summer peak periods. 2 combustion turbo alternators of 2500 kw. and one of 1875 kw. are intended to provide standby power.—*H. E. Babbitt.*

The Water Supply of Holland. R. C. S. Walters. J. Inst. Wtr. Engrs., **4**:67 (Feb. '50). In '38 population of Holland was 8,700,000, of which 6,300,000 were provided with piped water. It is estimated that, in year 2000, 235 mgd. (Imp.) will be required. Amount of underground water available is 90 mgd. (Imp.). Deficiency to be made up by surface water. Reasonable figure for replenishment of underground water is 72 gpd./sq.yd. Principle adopted for water supply of Amsterdam was to drain permeable sand dunes. Today there are 24 mi. of canal cut into dunes, draining all available water from 9200 acres to main pumping station. There are, in addition, 486 boreholes. Avg. percolation about 75% of annual rainfall. Part of Amsterdam's supply derived from lakes situated among centers of habitation. Villages on banks discharge untreated sewage into them. Self-purification very intensive. Lake Loenderveen is among purest surface water of country; its M.P.N. of *Esch. coli* is 1–3/100 ml. Great advantage of lake water is scarcity of plankton organisms due to absence of phosphates. Peat responsible for high color and organic matter. Provincial supply for over 2,000,000 people on 1000 sq.mi. in north Holland depends on 360 wells up to 250′ deep in dune collecting area of 12,038 acres. Investigation of safe yield by large percolation gages or lysimeters now in progress. Water at Noordbergum, derived from coarse sands, contains so much iron and manganese that it is aerated intensively and filtered twice.—*H. E. Babbitt.*

Fluorine Content in Well Water Supplies in the Province of Warsaw [Poland]. J. Dzułynska & J. Just. Gaz, Woda i Tech. Sanit. (Poland), **24**:186 (May '50). Of 1846 wells examd. in Warsaw Province (noted as public or semipublic wells), only 14 showed fluoride concns. in range of 0.5–1.0 ppm. None showed greater concns. Authors conclude that dental fluorosis due to drinking water not probable and that fluorine content of waters not sufficiently great to serve as prophylactic measure against dental caries.—*Conrad P. Straub.*

Filtration of Water [Poland]. Witold Chramiec. Gaz, Woda i Tech. Sanit. (Poland), **24**:130 (Apr. '50). Article presents review of author's experiences with filters in Upper Silesia during '29–'49. Slow sand filters alone were in use until '48 when 2 rapid sand filters of proposed total of 12 placed in operation. Some plain sedimentation provided prior to filtration. Coagulation not practiced. Source of supply very clean. Proposal made that studies be carried out on sedimentation before additional sedimentation units installed. In 1940 slow sand filters operated at 4.8-mgd. rate. Rapid sand filter rate of operation about 128 mgd. Length of runs between washes rather interesting, since according to author, they seem reversed. Slow sand filters operate only 10–14 days between washes and rapid sand filters 30–45 days. Slow sand filters washed in place by means of special device developed under author's direction some years ago, and rapid sand filters washed in conventional manner with water and air but for 15 min. Difference in length of runs between washes attributable to

(*Continued on page 74*)

Threshold Treatment with CALGON* stabilizes dissolved iron and manganese

"Red Water" complaints do not necessarily mean that active corrosion is occurring in a water system.

In unfiltered well waters such complaints may be caused by the oxidation and subsequent precipitation in the mains of iron present in the water at its source. A concentration of only a few tenths of a part per million can cause difficulty because the sludge will build up in the mains and eventually be carried through to the consumer.

Threshold Treatment with Calgon, however, will prevent the precipitation of hydrous ferric oxide upon exposure of an iron-bearing water to air or even to free residual chlorination. When so treated, the water will remain clear throughout the system. The water will be colorless, for all practical purposes, and will not stain clothes or textiles processed with water.

The treatment is equally effective in regard to manganese-bearing waters, which are the source of "black water" complaints.

For more detailed information on the use of Calgon in stabilizing dissolved iron and manganese, or on specific problems in which you are interested, write to Calgon, Inc., Hagan Building, Pittsburgh 30, Pa. Calgon technical representatives are at your service.

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(*Continued from page 72*)

fact that water contains some iron which tends to be retained near surface in slow sand filters, clogging them, whereas with higher flow rates in rapid sand filters, iron distributed throughout filter. From data presented, there is little difference in quality of water produced by two methods. In conclusion author states: [1] experimental studies should det. most appropriate sizes for sand for rapid and slow sand filters; [2] cost of constructing slow sand filters may be reduced by operating them at higher rates; [3] operating costs may be decreased considerably by cleaning slow sand filter in place by means of mechanism developed by author; [4] cost of construction of rapid sand filters may be reduced by simplifying pipe system for influent, effluent and air; [5] max. head loss on rapid sand filter should be detd. experimentally; [6] problem of sedimentation requires special study; and [7] plant described lends itself to establishment of experimental station for study of sedimentation and filtration.—*Conrad P. Straub.*

FLUORIDATION

Control of Dental Caries by the Addition of Fluorides to Public Water Supplies. FRANCIS A. BULL. J. Am. Dental. Assn., **41**:2:146 (Aug. '50). Question now before many communities: "Is evidence for fluoridation of public water supplies sufficiently conclusive to warrant its general recommendation to public?" Two viewpoints govern answer: [1] evidence is conclusive and fluoridation should begin now; [2] evidence is presumptive and fluoridation should be deferred until conclusive. Although scientific skepticism is healthy, it must be based on logical deductions. When there is overwhelming epidemiologic evidence to support any public health measure, skepticism not founded on logical bases should not constitute valid reason for withholding that measure from public. History of public health is filled with examples of great harm done to public because skepticism was maintained long after it had ceased to be scientific or logical. Wisconsin Board of Health believes that evidence is sufficiently conclusive to recommend fluoridation of all water supplies. Wisconsin Dental Soc. resolved to condemn fluoride-deficient water supplies as unfit for children to drink. As a result, 80% of urban pop. of state has adopted fluoridation. Drawbacks to fluoridation: [1] does not help rural population; [2] is not cure-all—children born and raised in communities fluoridating their drinking water will still have ⅓ of their present caries incidence.—*F. J. Maier.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals, are listed below.

A Comparative Study of Presumptive Media for the Coliform Group, H. J. FOURNELLE & H. MACY. Am. J. Pub. Health, **40**:8:934 (Aug. '50).

Simplified Dissolved-Oxygen Computations. M. LEBOSQUET JR. & E. C. TSIVOGLOU. Sew. Ind. Wastes, **22**:8:1054 (Aug. '50).

Aquatic Weed Control with Sodium Arsenite. KENNETH M. MACKENTHUN. Sew. Ind. Wastes, **22**:8:1062 (Aug. '50).

Asphalt Underseal Restores Canal. J. R. BENSON & L. M. ELLSPERMAN. Eng. News-Rec., **145**:5:35 (Aug. 3, '50).

Additional Supply for Mexico City From Lerma Project. EDUARDO MOLINA. W. W. Eng., **103**:8:706 (Aug. '50).

Design and Operation of Outdoor Swimming Pools. JOHN C. BUMSTEAD. Eng. News-Rec., **145**:7:33 (Aug. 17, '50).

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under the most difficult, adverse conditions

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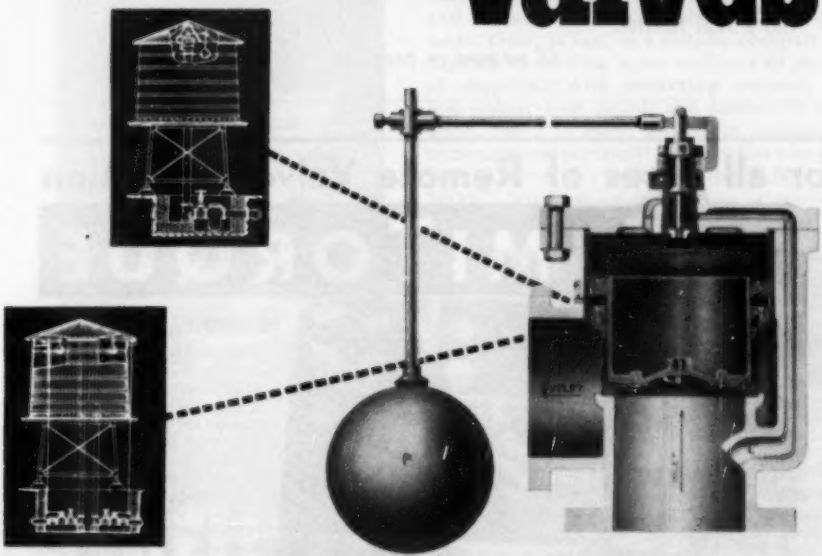

Golden-Anderson engineers have pioneered the development of float operated valves for cold and hot water requirements in elevated tanks. These valves are the quick opening type or semi-throttling design, and arranged with either integral or remote pilot control for differential water level operation.

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FOR OVER 30 YEARS

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(*Continued from page 22*)

James C. Hanes, formerly sanitary engineer with the Institute of Inter-American Affairs, has been appointed chairman of the Dept. of Civil Engineering at Rutgers University, N.J.

A portable pump designed especially to test and sterilize water mains has been improved by Porto Pump, Inc., 227 Iron St., Detroit 7, Mich. The pump is a rotary, positive displacement type utilizing rubber gears and can develop pressures up to 200 psi. for hydraulic testing.

Copied, without permission, from the September 9, 1950, issue of *The New Yorker* magazine was this grisly bit:

While painting the water tower at Osceola, Ia., Donald Jones of Clear Lake, Ia., fell some 20 feet into the tower. To get him out, a hole was cut in the bottom of the tank, through which the injured man was removed on a sling. To keep Jones company during the cutting operation, William Sutton descended into the tank. Sutton is an employe of an Osceola funeral home.—*Burlington (Iowa) Hawk-Eye Gazette.*

And a real hustler.

(*Continued on page 78*)

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(*Continued from page 76*)

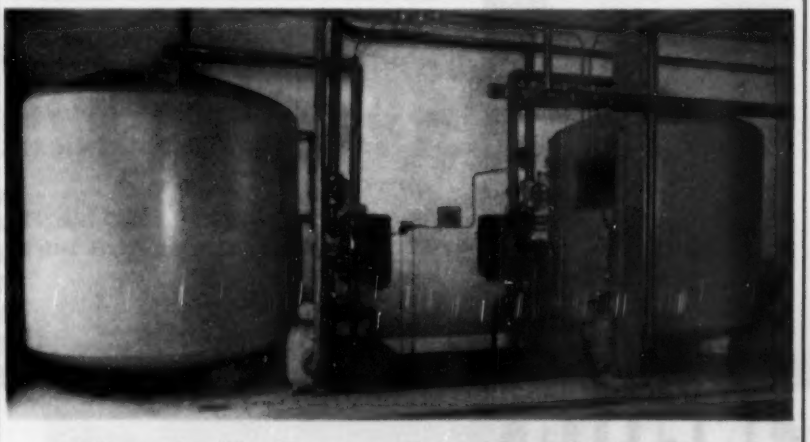
L. P. Seyb, chemist and group leader in the Research Dept. of Diamond Alkali Co., has been appointed manager of research. He succeeds J. E. Underwood, who will act as research consultant to the company.

A sample cooler for boiler and boiler feedwater samples has been developed by Worthington Pump & Machinery Corp. The device is constructed of stainless steel and utilizes a shell and tubular coil type heat exchanger to convert samples at pressures of 1,500 psi. and temperatures of 600°F. to pressures of 150 psi. and temperatures approaching those of the coolant.

Burton L. Oliver has formed the municipal consulting firm of B. L. Oliver & Co., Box 465, Kansas City 10, Mo. He had previously been chief engineer for E. T. Archer & Co. of the same city.

A mercury manometer designed to minimize breakage has been produced by E. Machlett & Son, New York. The Teschner-Machlett instrument utilizes a Bennert scale.

(*Continued on page 80*)



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WELL WATER SYSTEMS
VERTICAL *Turbine* PUMPS

(Continued from page 78)

James M. Robinson of Hornell, N.Y., has been appointed sales engineer representing A. P. Smith Mfg. Co. in New York and New Jersey.

A new Los Angeles district office has been established by Hagan Corp. and its subsidiaries, including Calgon, Inc., at 3931 Tweedy Blvd., South Gate, Calif. The previous address was 1807 East Olympic Blvd., Los Angeles.

An electric-powered cleanout auger for 3-in. waste and water lines has been placed on the market by General Wire Spring Co., Pittsburgh, Pa. The "Handyelectric" auger is equipped with two 25-ft. snakes, cutter blades, drill and boring gimlet. The unit is so designed that the only moving parts are the chuck and snake. The unit can be used as an electric drill with the auger snake removed.

Leakproof fittings which offer a vacuum-tight seal on instrument and other tubing are being offered by the Crawford Fitting Co. of Cleveland, Ohio. The Swagelok fittings, available in a variety of metals and alloys to fit tubing from $\frac{1}{8}$ to 1 in. od., feature two ferrules and a threaded chuck which clinches them tight against the fitting wall.

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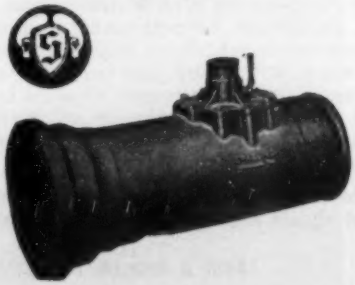

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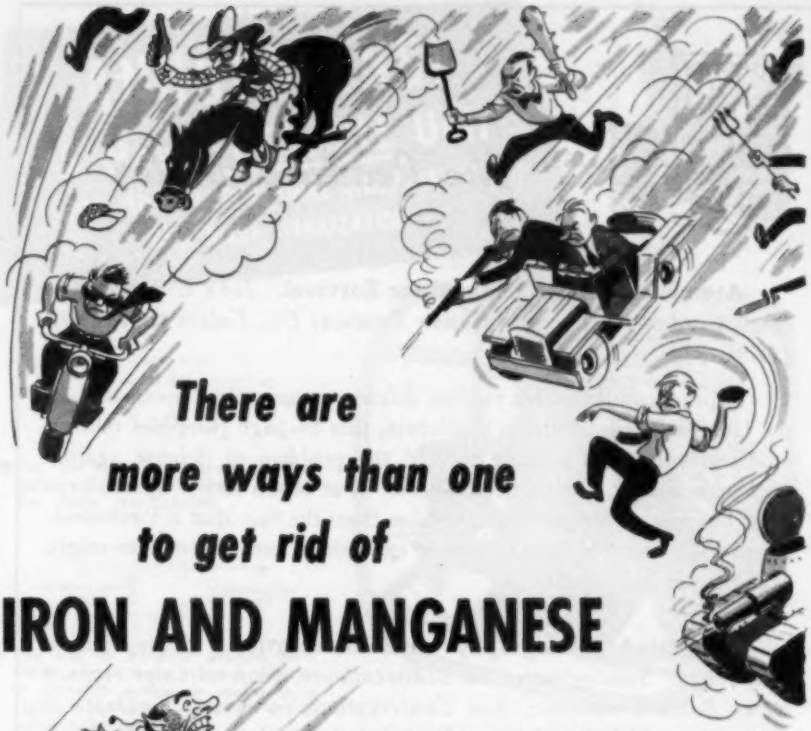

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The Reading Meter

Atomic Attack—A Manual for Survival. *John L. Balderston Jr. & Gordon W. Hewes. Culver Products Co., Culver City, Calif. (1950) $1*

A practice manual for civilian defense organizations sponsored by the University of Southern California, this 64-page pamphlet takes a moderately hopeful attitude toward the problem of defense against nuclear weapons. "You need not die" is at best a rather dismal keynote, but the booklet derives its value from the fact that a foreknowledge of the concrete facts of atomic explosions and their effects might save lives.

Annotated Bibliography on Sedimentation. *Sedimentation Bul. No. 2, Subcommittee on Sedimentation, Federal Inter-Agency River Basin Committee, Soil Conservation Service, U.S. Dept. of Agriculture (1950) $1.25. [Distributed by Supt. of Documents, U.S. Government Printing Office, Washington, D.C.]*

Begun as a WPA literature research project in 1938, this 350-page bibliography has been continued and, after a wartime interruption, has now been brought up to date, including an estimated 90-plus per cent of the important articles published in English prior to January 1, 1950. References to unpublished theses and translations of foreign works are included. A short abstract accompanies each of the listings, which are arranged alphabetically by authors. A subject index is included.

A.C.I. 20-Year Index: Index to the Journal of the American Concrete Institute, 1929–1949. *American Concrete Institute, 18263 W. McNichols Road, Detroit 19, Mich. (1950) $2*

Included with the alphabetical index are synopses, in chronological order, of all papers, reports and other technical literature published by A.C.I. in the past two decades.

(Continued on page 84)

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A New PORTABLE Unit

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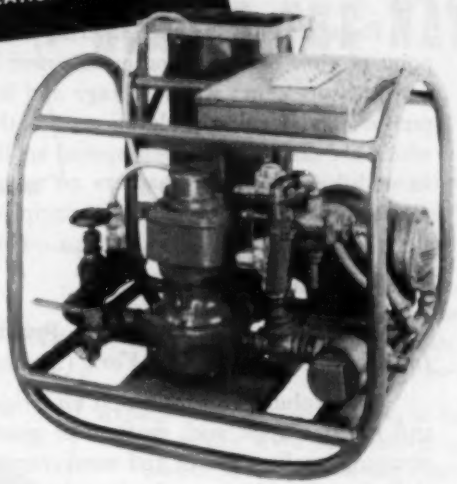

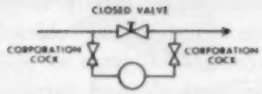

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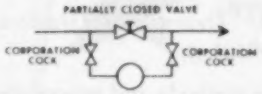

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You don't need electricity or other outside power for this unit — it operates hydraulically, driven by the main line pressure. Chemical feeding is automatically maintained in exact proportion to the flow through the main, with feeding rates adjustable up to 5 gals. per hr. at pressures from 15 to 100 p.s.i.

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The Reading Meter

(*Continued from page 82*)

Moisture Requirements in Agriculture: Farm irrigation. *Harry Burgess Roe. McGraw-Hill Book Co., New York (1950) $5.50*

Requirements for the watering of crops are discussed from the point of view of the irrigation engineer in this text. Hydraulic flow and measurement; water storage and losses; weirs, gates, pipes and pumps; and legal considerations are the usual water supply topics which are discussed in their special application to irrigation problems. In addition, there are chapters on such specialized subjects as soil-moisture relations, irrigation principles and methods and farming and the irrigation of various crops. Primarily a book for the irrigation engineer.

Irrigation Principles and Practices. *Orson W. Israelsen. John Wiley & Sons, New York (2nd ed., 1950) $6*

This volume is a basic text on irrigation methods and procedure, and touches upon such matters of general water supply interest as pumping, wells, rainfall and measurement from the agricultural specialist's point of view. In its own field it appears to be a mine of information, and the water superintendent who feels that an understanding of the subject will be useful to him should find this an interesting and informative exposition. Otherwise it is, like the one above, a book for the specialist.

Unit Operations. *George Granger Brown et al. John Wiley & Sons, New York (1950) $7.50*

Among the industrial processing operations discussed in this large textbook are a number of interest to the water supply field. Sections on fluids, sedimentation, pipe, flow, metering, pumping and filtration are covered both theoretically and by illustrated descriptions of equipment in action. In the sections which range farther afield, into materials handling, screen analysis (of filter media, for example), heat transfer and other topics, might be found information useful to the water works man in the pursuit of his varied operations as a plant manager, although not normally considered within his scope. The volume was planned as a textbook, however, and many chapters which the superintendent will try to skim for incidental information may prove heavy going.

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Service Lines

A bulletin on the "Pressureflo Control" system for automatic pump control (September P&R, p. 20) has been issued by the manufacturer. Builders-Providence, Inc., Providence 1, R.I.

Asbestos yarning rope for calking bell and spigot joints is now being offered by Johns-Manville, 22 E. 40th St., New York 16, N.Y. The details are contained in a four page bulletin available from the company.

"Research Facilities Without Capital Investment" is the title of a 20-page brochure describing the services offered by Foster D. Snell, Inc., 29 W. 15th St., New York 11, N.Y.

An adapter for installing Flowrator meters in horizontal piping without excessive loss of headroom is among the features of Fischer & Porter Co. catalog section 25E. Copies are obtainable from the company at 25 County Line Road, Hatboro, Pa.

An 80-page catalog of "Kardex" visible record controls has just been issued and is available on demand from the Management Controls Div. of Remington Rand, Inc., 315 4th Ave., New York 10, N.Y.

Asbestos-bonded drainage pipe for severe service conditions is offered by Armco Drainage & Metal Products, Inc., Middletown, Ohio, and described in a 6-page folder showing typical installations and performance records under highly corrosive conditions.

(Continued from page 88)

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This city's demands for water were expanding. Two wells and the pumping facilities appeared inadequate. No overhead reservoir was available. Financing a third well and pumps was impractical. Water wastage (before installing Badger Meters) seemed excessive. The city decided to try metering as a means of reducing waste. Result: after metering, 24-hour flow was reduced over 55%. No new well needed. The water supply problem was solved . . . so was the financing problem! You, too, will find "It pays to BUY BADGER".

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Presents the facts of life (and death) of the facilities of water supplies serving almost 10 per cent of all U. S. consumers plus 400,000 Canadians.

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American Water Works Association
500 Fifth Avenue New York 18, N. Y.

(Continued from page 86)

A modern American "Flocsettler" is the subject of Technical Supplement FL, an 8-page bulletin available from American Well Works, Aurora, Ill.

"Monobloc" centrifugal pumps are described in a new bulletin, W-306-B1, issued by Worthington Pump & Machinery Corp., Harrison, N.J. An 11-page section entitled "How to Select a Cold Water Pump" is included.

"Inversand" zeolite-type water softeners are the subject of a new bulletin, V-11, issued by Hungerford & Terry. Various types of automatic and semi-automatic units employing poppet-type multiport valves are described and discussed.

Recording gages in the Series 500 line of Bristol Co. are the subject of a 32-page bulletin, G621, just published. Copies are available from the company, which is located at Waterbury 20, Conn.

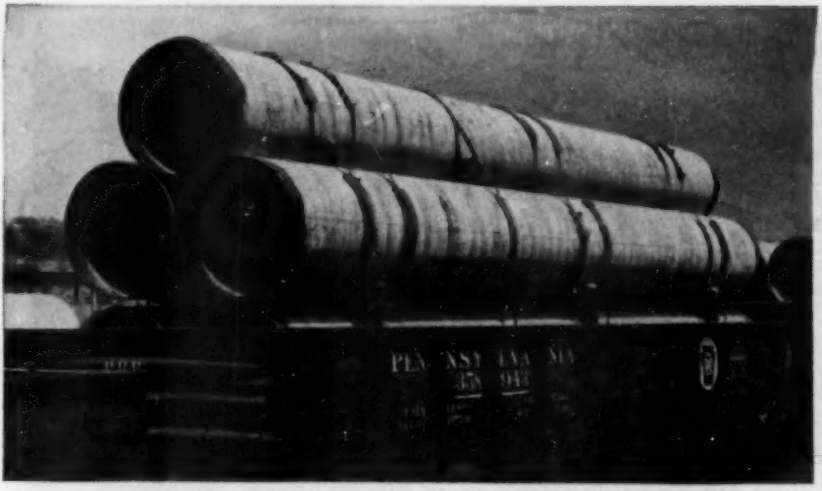
A line of Omega Universal Feeders capable of feeding from 1 to 5,000 lb. of chemical per hour is the subject of a 12-page bulletin, No. 20-G14, issued by Omega Machine Co., Providence 1, R.I. Mechanical details and dimensions of the units, which are designed to handle practically all types of dry chemicals, are included.

HOW WATER WORKS WORK

may be learned from a proper interpretation of "A Survey of Operating Data for Water Works in 1945"—a comprehensive tabulation of rates, income, costs and other vital statistics for 462 utilities serving communities of over 10,000 population. Reprinted from the February 1948 JOURNAL.

96 pages 50 cents

American Water Works Association
500 Fifth Avenue New York 18, N. Y.



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In City after City

there's a reason

In Cleveland, Savannah, Minneapolis, Cincinnati, and scores of other American cities, the trend is toward Bethlehem Tar-Enameled Water Pipe for supply line service. And for good reason.

Bethlehem Tar-Enameled Water Pipe is ideal for the water supply lines of progressive cities because of the way it combats incrustation and corrosion. It is precision-formed from heavy plate steel, and is then carefully welded, after which it is coated uniformly with a generous layer of protective tar enamel, in accordance with American Water Works Association Code.

Bethlehem Tar-Enameled Water Pipe is long-lasting, and is economical to install, as all field joints can be made with ease. It offers flexibility of design. Elbows can be made to any degree of deflection in the line, enabling the user to bypass obstructions with minimum difficulty. The pipe comes in sizes from 22 in. up to the largest permitted by shipping clearances, and in lengths up to and including 40 ft. When diameters are too large for convenient handling, it can be shipped knocked down for assembly in the field.

Should you have any questions about Bethlehem Tar-Enameled Water Pipe, put them up to the nearest Bethlehem sales office, or write to us at Bethlehem, Pa.

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BETHLEHEM *Tar-Enameled* WATER PIPE

Section Meeting Reports

New York Section: The annual Fall Meeting of the New York Section was held at Saranac Inn, Upper Saranac Lake, N.Y., on September 7th and 8th.

It was unanimously voted by the Section that the fall meetings should always be held at some resort hotel in the mountains. This plan has been followed in the past three years with great success. Special rates have been obtained, and the meeting at Saranac Inn, like the others, was very attractive and well attended. The entertainment and delightful facilities afforded by these hotels have proven very successful, and many of the members' wives have attended.

Dr. A. E. Berry, a long-time and well-known Secretary of the Canadian Section, who has recently been made Vice-President of the Association, presented an excellent address on national Association affairs. Richard L. Rosenthal, president of the New York Water Service Corp., New York City, presented a paper of interest not only to private but also to municipal water departments on the subject "Random Thoughts on Financing, Returns and Rate Problems." His paper covered many new aspects of financing and rate problems that have arisen in recent years, as a result of increased costs of labor and materials.

"Problems of Cold Weather Operation of Water Works" was the subject discussed by E. J. Van Deusen, superintendent of the Water Dept. of Malone, N.Y. Malone is located almost on the Canadian border, on the fringe of the Adirondack Mountains, where cold weather problems have to be met, and the paper analyzed these difficulties and their solutions.

Perhaps the keynote of the entire meeting was the urgent and current problem of "Civil Defense for Water Works," presented very ably by Earl Devendorf, director of the Division of Environmental Sanitation, State Department of Health, Albany, N.Y. The speaker was recently appointed by Governor Dewey as Civilian Defense Director for Water Works in New York. His splendid record during World War II, in a similar capacity, will serve him in good stead in the current planning, which he has already

(Continued on page 92)

WW-14

EIGHT DE LAVAL PUMPS*

Installed by CHESTER Municipal Water Authority

To meet increasing water requirements, the Chester Municipal Water Authority has established a new intake and filtration plant at Oxford, Pa., equipped with 8 De Laval Pumping Units having a total capacity of 56 mgd.

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(Continued from page 90)

undertaken. Coordinators have already been appointed in various regions, and a Section Committee assembled, representing all branches of the water works industry, to cooperate in the civilian defense effort.

George Moore of the State Dept. of Health, who has recently returned from Washington from a series of studies on the atomic bomb and its effects, offered recommendations on how best to prepare for this type of warfare.

The banquet was followed by an address on employee relations by John Spencer, assistant manager of employee, community and union relations in the Apparatus Dept. of General Electric Co., Schenectady, N.Y. He discussed labor-management cooperation in the company, with many suggestions that could well be applied in the water works field. Preceding the Round Table Conference and Panel Discussion, led by S. P. Carman, consulting engineer of Binghamton, N.Y., was a showing of the film "Waverly Water Dept.," presented and prepared by Lester R. Marshall, superintendent of the utility. Although Waverly is a comparatively small city, this film is excellent as a public relations activity, and is instructive not only to the layman but to the water works operator as well.

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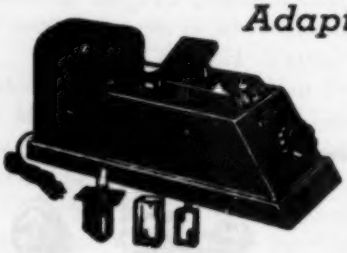

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Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

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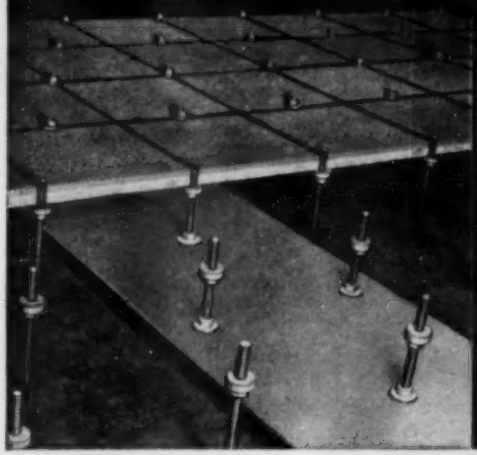

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COMING MEETINGS

(Continued from page viii)

October **26–27**—Iowa Section at Fort Des Moines Hotel, Des Moines. Secretary: H. V. Pedersen, Supt. of Water Works, Municipal Bldg., Marshalltown, Iowa.

26–28—New Jersey Section at Hotel Madison, Atlantic City, N.J. Secretary: C. B. Tygert, Wallace & Tiernan Co., Box 178, Newark 1, N.J.

30–31—Maritime Water Works Association at Admiral Beatty Hotel, St. John, New Brunswick, Canada. Secretary: J. D. Kline, 601 Barrington St., Halifax, N.S.

November **1–3**—Chesapeake Section at Du Pont Hotel, Wilmington, Del. Secretary: Carl J. Lauter, 5902 Delecarlia Pl., N.W., Washington 16, D.C.

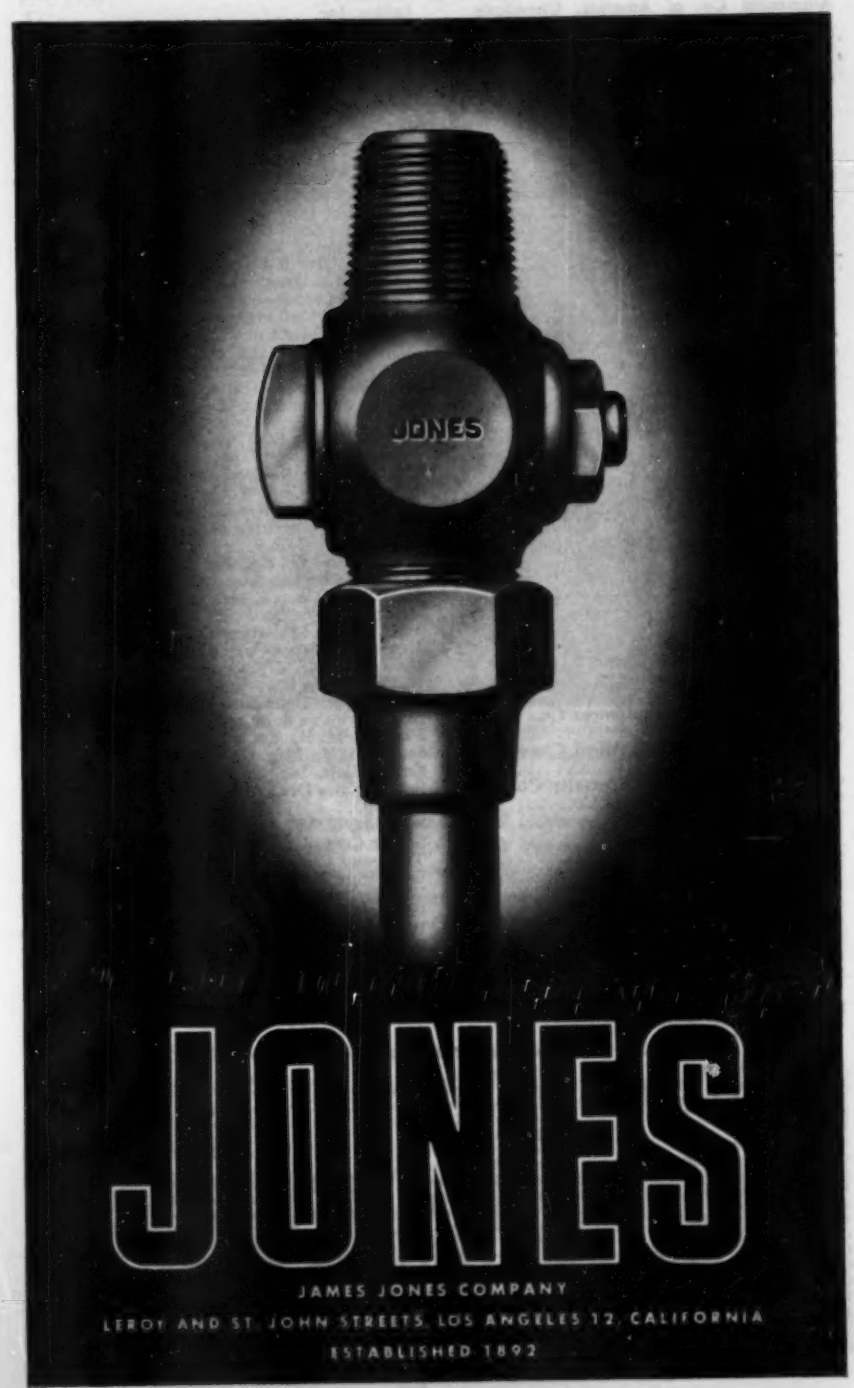
6–7—Virginia Section at Jefferson Hotel, Richmond, Va. Secretary: W. H. Shewbridge, Asst. Engr., State Dept. of Health, 708 State Office Bldg., Richmond 19, Va.

13–15—North Carolina Section at Washington-Duke Hotel, Durham, N.C. Secretary: E. C. Hubbard, Prin. San. Engr., State Board of Health, Raleigh, N.C.

13–15—Joint Cuban-Florida Water and Sewage Conference (Cuban and Florida Sections A.W.W.A. and Florida Sewage Works Assn.) at Governor's Club Hotel, Fort Lauderdale, Fla.

Nov. 30–Dec. 2—Arizona Section at Pioneer Hotel, Tucson, Ariz. Secretary: Mrs. Helen Rotthaus, San. Eng. Div., State Dept. of Health, Phoenix, Ariz.

January 16, 1951—New York Section Luncheon Meeting at Park-Sheraton Hotel, New York, N.Y. Secretary: R. K. Blanchard, Vice-Pres. & Engr., Neptune Meter Co., 50 West 50th St., New York 20, N.Y.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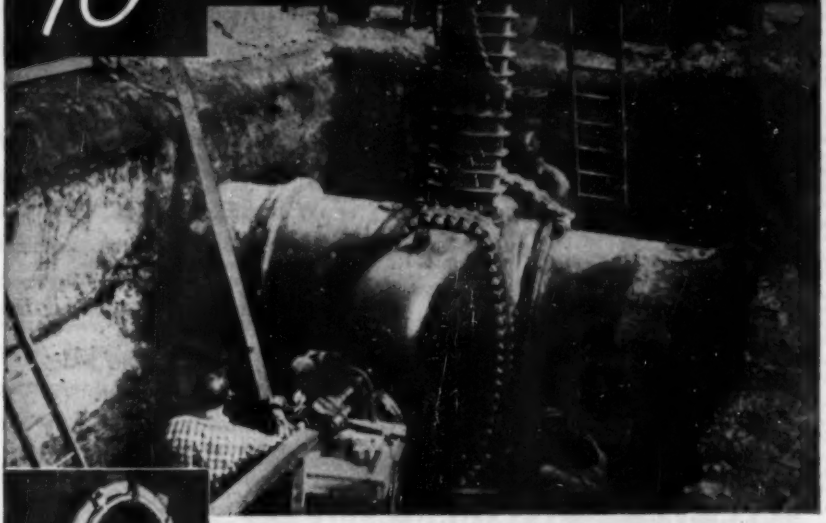
to Avoid Stoppage of Steel Production



Section removed from main

Finished Insertion

CUTTING THE MAIN. Illustration shows cutting dome, temporary shut-off valve and permanent valve body in place.

At a large Eastern steel mill uninterrupted production depended upon a thirty year old, 48" cast iron main, carrying sea water used for cooling the furnace jackets. The main was in poor condition — badly corroded and electrolytically pitted.

In order to provide an emergency by-pass in the event of line failure, a gate valve was required. Since the mill could not risk even a momentary shut down, Smith was asked to insert the valve under pressure. Although of unprecedented size, the insertion was completed in four days without interruption of service or reduction in pressure.

*First 48" insertion ever made under pressure. One month later a second 48" gate valve was inserted by Smith for the Water Bureau, Philadelphia, Pa.

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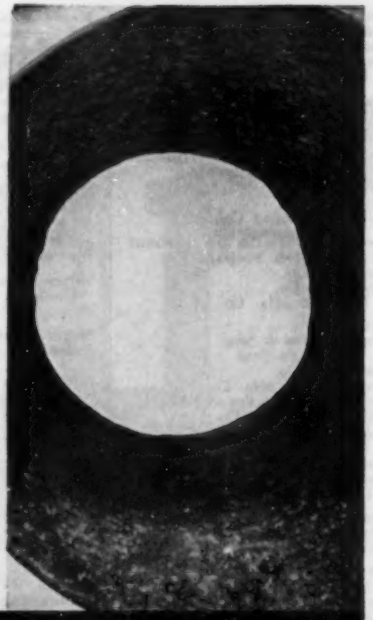

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Roberts Filter Mfg. Co.
Rohm & Haas Co.

Iron Removal Plants:
American Well Works
Chain Belt Co.
Cochrane Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

Jointing Materials:
Atlas Mineral Products Co.
Michael Hayman & Co., Inc.
Hydraulic Development Corp.
Leadite Co., Inc.
Northrop & Co., Inc.

Joints, Mechanical, Pipe:
Carson-Cadillac Co.
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
Dresser Mfg. Div.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Laboratory Reagents:
Ohio Research & Testing Labs.

Leak Detectors:
Jos. G. Pollard Co., Inc.

Lime Slakers and Feeders:
Dorr Co.
Infilco, Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)

Magnesium Anodes (Corrosion Control):
Dowell Incorporated

Manometers, Rate of Flow:
Builders-Providence, Inc.

Meter Boxes:
Art Concrete Works
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.
Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
James Jones Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Smith-Blair, Inc.
Worthington-Gamon Meter Co.

Meter Reading and Record Books:
Badger Meter Mfg. Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc.
Infilco, Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
A. P. Smith Mfg. Co.
R. W. Sparling
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Chain Belt Co.
Infilco, Inc.
Walker Process Equipment, Inc.

Ozonation Equipment:
Welsbach Corp., Ozone Processes Div.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe, Cement Lined:
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Dearborn Chemical Co.
Koppers Co., Inc.
Warren Foundry & Pipe Corp.

Pipe, Concrete:
American Pipe & Construction Co.
Lock Joint Pipe Co.
Price Bros. Co.

Pipe, Copper:
American Brass Co.

Pipe Cutting Machines:
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators:
Jos. G. Pollard Co., Inc.

Pipe, Plastic:
Carter Products Corp.

Pipe, Steel:
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.

Pipelines, Submerged:
Boyce Co., Inc.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Warren Foundry & Pipe Corp.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Centrifugal:
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Morse Bros. Mchy. Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Chemical Feed:
Infilco, Inc.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Pumps, Diaphragm:
Dorr Co.
Morse Bros. Mchy. Co.
Proportioneers, Inc.

Pumps, Hydrant:
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.

Pumps, Sewage:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Peerless Pump Div., Food Machinery Corp.

Pumps, Sump:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Peerless Pump Div., Food Machinery Corp.

It's the Last Word!

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Fluoridizer

FOR LOW COST FLUORIDATION

Here's a Sodium Fluoride feeder that's highly accurate, entirely dependable, and low in cost. It provides safe, volumetric feeding of Sodium Fluoride for tooth decay control programs in town or city water systems. The hopper holds a day's supply, sufficient for treating up to 3 MGD.

You'll agree the Omega Fluoridizer is the last word in feeders when you check these outstanding features:

1. **Fluoridizer cannot flood or overfeed.**
2. **Variable speed drive gives positive control of rate of feed from 0 to 100 ounces per hour on dial.**
3. **Weigh scale gives double check on amount fed.**
4. **Large stainless steel dissolver insures proper chemical solution. Since it is not mounted on the scale, errors due to variable weight of the water are eliminated.**
5. **Machined groove in feeding disc provides positive volumetric measurement of material fed.**
6. **Hopper is instantly removable for cleaning — agitators prevent arching.**
7. **Driving mechanism is automatically lubricated at all points.**
8. **Installs easily. A complete unit should include a dust remover which is offered as an accessory.**

OMEGA PRODUCTS

Belt-Type Gravimetric Feeders • Loss-in-Weight Gravimetric Feeders • Universal Feeders • Rotolock Feeders • Lime Slakers • Laboratory Stirrers • Precision Solution Feeders • Disc Feeders • Rotodip Solution Feeders • Dust Collectors • Chemical Elevators

For Bulletin 50-G4 and complete information write Omega Machine Company (Division of Builders Iron Foundry), 365 Harris Ave., Providence 1, Rhode Island.

THE LAST WORD IN FEEDERS

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Pumps, Turbine.
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Rate Analysis:
Recording & Statistical Corp.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.

Recording Instruments:
Builders-Providence, Inc.
Infilco, Inc.
R. W. Sparling
Wallace & Tiernan Co., Inc.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves; see Clamps

Sleeves and Valves, Tapping.
James B. Clow & Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Cochrane Corp.
Permutit Co.

Soda Ash:
Solvay Sales Div.

Sodium Hexametaphosphate:
Blockson Chemical Co.
Calgon, Inc.

Softeners:
Cochrane Corp.
Dearborn Chemical Co.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Infilco, Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Storage Tanks; see Tanks

Strainers, Suction:
M. Greenberg's Sons
R. D. Wood Co.

Surface Wash Equipment:
Permutit Co.
Stuart Corp.

Swimming Pool Sterilization:
Everson Mfg. Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)

Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping Machines:
Hays Mfg. Co.
A. P. Smith Mfg. Co.

Taste and Odor Removal:
Cochrane Corp.
Industrial Chemical Sales Div.
Infilco, Inc.
Proportioneers, Inc.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Telemeters, Level, Pump Control, Rate of Flow, Gate Position, etc.:
Builders-Providence, Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
Central Foundry Co.
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
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M. Greenberg's Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
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Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Dearborn Chemical Co.
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dearborn Chemical Co.
Dorr Co.
Everson Mfg. Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Stuart Corp.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Well Acidizing:
Dowell Incorporated

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1948 Membership Directory.

Bad in a door— worse in a Valve

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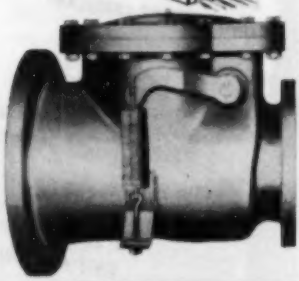
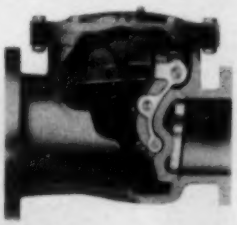
CHECK VALVES

Seat without **SLAM**



THERE'S always possibility of serious SLAM trouble on pump shut down especially where gradient is steep or where pumps are manifolded and shut down individually. Rensselaer check valves solve this problem, END this trouble—yet their construction is simple, and head loss comparatively low. Their lever-and-adjustable-spring-construction eliminates SLAM by seating the gate at the same instant the water column in the discharge line comes to rest. These valves are ideal for pumping plants; water, oil, gasoline; chemical and process industries; marine service, drydocks; fire protection systems. For complete data, see new Catalog H.



Heavy Stainless Steel Main Hinge Shaft...Heavy Solid Bronze Gate Hinge...Stainless Steel Key...Dual Stainless Steel Gate Pins... Rugged Cast Iron Bronze Mounted Gate. See your Rensselaer Representative for seasoned advice on all our products.

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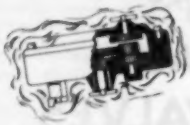
DISC METER USERS . . .
LOOK AT THESE PLUS VALUES!

Rockwell
ARCTIC AND TROPIC
DISC TYPE
WATER METERS

REGISTERS WITH SWEEP DIAL TEST HANDS . . .


ENCLOSED GEAR TRAIN HOUSING THAT RETAINS LUBRICANT . . .

THE ECONOMY OF THREE-PART REINFORCED DISCS . . .

THE REPAIR EASE RESULTING FROM UNIT ASSEMBLY OF WORKING PARTS . . .

Rockwell brings you all these features in a *balanced* disc meter design that for many years has been noted for its accuracy and overall measurement economy.

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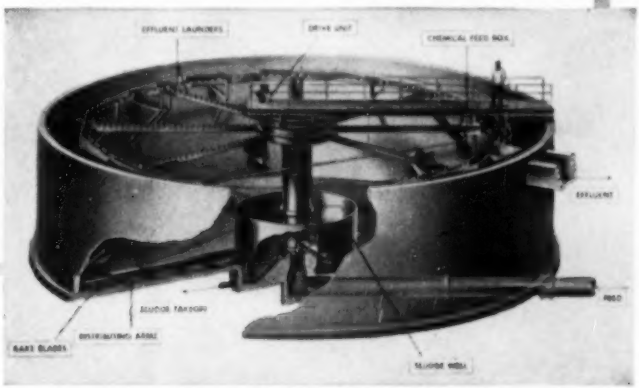
LET'S LOOK AT THE FACTS

when selecting HIGH-RATE units for industrial water treatment!

You want the best . . . when you select high-rate units for the removal of hardness, turbidity, color or algae from your process water.

Here are six basic reasons why you should select Dorrco Hydro-Treators . . . for the *best* results . . . at *lower* cost:

- ✓ Uniform, low turbidity effluent
- ✓ Exceptionally low moisture content in discharged sludge
- ✓ Positive, continuous sludge removal
- ✓ Low installed cost
- ✓ No "slug loading" on adjacent streams
- ✓ Minimum power requirements



THE DORRCO HYDRO-TREATOR

Overflow launder arrangement illustrated used on larger sizes. Arrangement varies with size of unit.

If you are investigating high-rate, up-flow type units for industrial water treatment, get all the facts before deciding. A Dorr engineer will gladly supply detailed figures and operating results . . . at no obligation.

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Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

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